ARMY RESEARCH LABORATORY

An Annotated Bibliography of Studies and Reports Produced by the Advanced Decision Architectures Consortium of the Collaborative Technology Alliance From 2001 to 2010

by Sam E. Middlebrooks, Ph.D.

ARL-SR-219 **December 2010**

NOTICES

Disclaimers

Army Research Laboratory
Aberdeen Proving Ground, MD 21005-5425

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Human Research and Engineering Directorate, ARL

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14. ABSTRACT The purpose of the Advanced Decision Architectures (ADA) Collaborative Technology Alliance (CTA) was to design, test, and transition new cognitive and computer science innovations to facilitate better Soldier understanding of the tactical situation, more thorough evaluation of courses of action, and, ultimately, better and more timely decisions. The ADA CTA was conducted from 2001 to 2009, with final reports being published in 2010. It had four research area technical objectives: (1) cognitive modeling and metrics, (2) team communication and collaboration, (3) context-sensitive information presentation, and (4) fusion and intelligent architectures. This annotated bibliography documents the ADA CTA body of work and provides glimpses, through report abstracts, of the work performed in pursuit of each of these technical objectives.						
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Abstract.

"The purpose of the Advanced Decision Architectures (ADA) Collaborative Technology Alliance (CTA) was to design, test, and transition new cognitive and computer science innovations to facilitate better Soldier understanding of the tactical situation, more thorough evaluation of courses of action, and, ultimately, better and more timely decisions."[2] The ADA CTA was conducted from 2001 to 2009 with final reports being published in 2010. It had 4 research area technical objectives:

"Cognitive Modeling and Metrics
Advance human decision-making technologies through research on cognitive processing, modeling, and metrics to serve as a basis for describing individual and team accomplishment of the tasks to be performed.

Team Communication and Collaboration
Develop analytical tools and techniques to increase shared situational awareness for collaborative decision-making in real-time, distributed, mobile environments.

Context-Sensitive Information Presentation
Reduce physical and cognitive complexity of Soldier-system interaction by developing approaches for integrating information over diverse sources and perspectives, multiple modalities, and for mixed human-system/agent teams.

Fusion and Intelligent Architectures
Support both end-user applications and the computational and communication infrastructure via developing intelligent architectures for fusion and planning and agile computing approaches for decision support."

This annotated bibliography documents the ADA CTA body of work and provides glimpses, through report abstracts, of the work performed in pursuit of each of these technical objectives.

[2] http://www.arl.army.mil/www/default.cfm?Action=93&Page=153

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1. Introduction.

This purpose of this annotated bibliography is to document the research and resulting reports and publications produced by the Advanced Decision Architectures (ADA) consortium of the Collaborative Technology Alliance (CTA) between the U.S. Army Research Laboratory and industry and academia between 2001 and the conclustion of the CTA in 2010.

1.1. Performing Organizations.

The studies documented in this report were performed by the following organizations:

Figure 1 – Organizations Participating in the Collaborative Technology Alliance[1]

1.2. Research Objectives of the ADA CTA.

The study goals of the ADA CTA were divided into 4 Task Areas each with their own research objectives and research threads[4]. In the figures below those task areas with potential applicability to the Joint Data Management program are highlighted in green.

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[3] McDermott, P., & Allender, L. (Eds.). (2009). Advanced Decision Architectures for the Warfighter: Foundations and Technology: 48hrBooks by the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. **http://www.arladacta.info**.

1.2.1. Task Area 1: Cognitive Modeling and Metrics.

Research objectives:

- Design, test, and transition innovations to facilitate better Soldier understanding of the tactical situation, more thorough evaluation of courses of action, and, ultimately, better and more timely decisions

Accomplishments:

- Developed an efficient computational model of recognition-primed decision making
- Created models to describe interactions between fusion processes and decision making
- Conducted an experiment to determine how decision making intelligent agents can best assist S2 and S3 in the 3-Block Challenge scenario

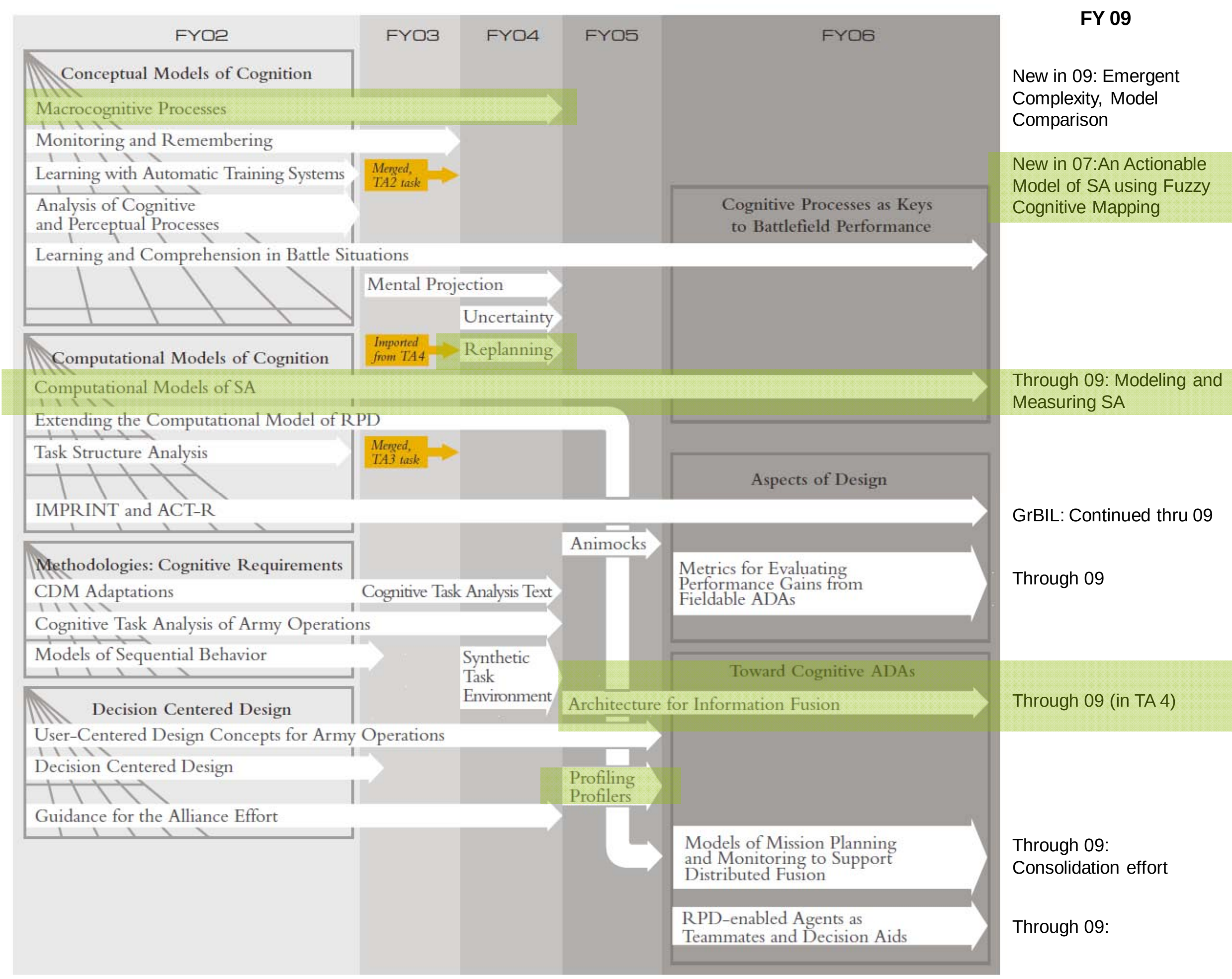

Figure 2- Cognitive Modeling and Metrics

Summary of Research Threads:

- Conceptual Models of Cognition.
- Cognitive Processes as Keys to Battlefield Performance.
- Computational Models of Cognition.

[4] ADA CTA Briefing by Patty McDermott, Alion Science and Technology, Inc. (2010)

- Aspects of Design.
- Methodologies: Cognitive Requirements.
- Toward Cognitive ADAs.
- Decision Centered Design.:

1.2.2. Task Area 2: Team Communication and Collaboration.

Research objectives:

- Create tools and intelligent systems that support collaborative decision making across distributed teams.
- Exploit information operations to provide data in meaningful ways to support shared SA, coordination, and adaptation.

Accomplishments:

- Improved distributed planning activities via Collaborative Slide Annotation Tool during CERDEC JF Experiment.
- Developed C2 network analysis toolkit to help commanders visualize C2 structures, analyze effectiveness and redesign the structure, if needed.
- Developed mission planning and replanning tools.
- Specified measures to predict team performance and subsequent impact on system performance.

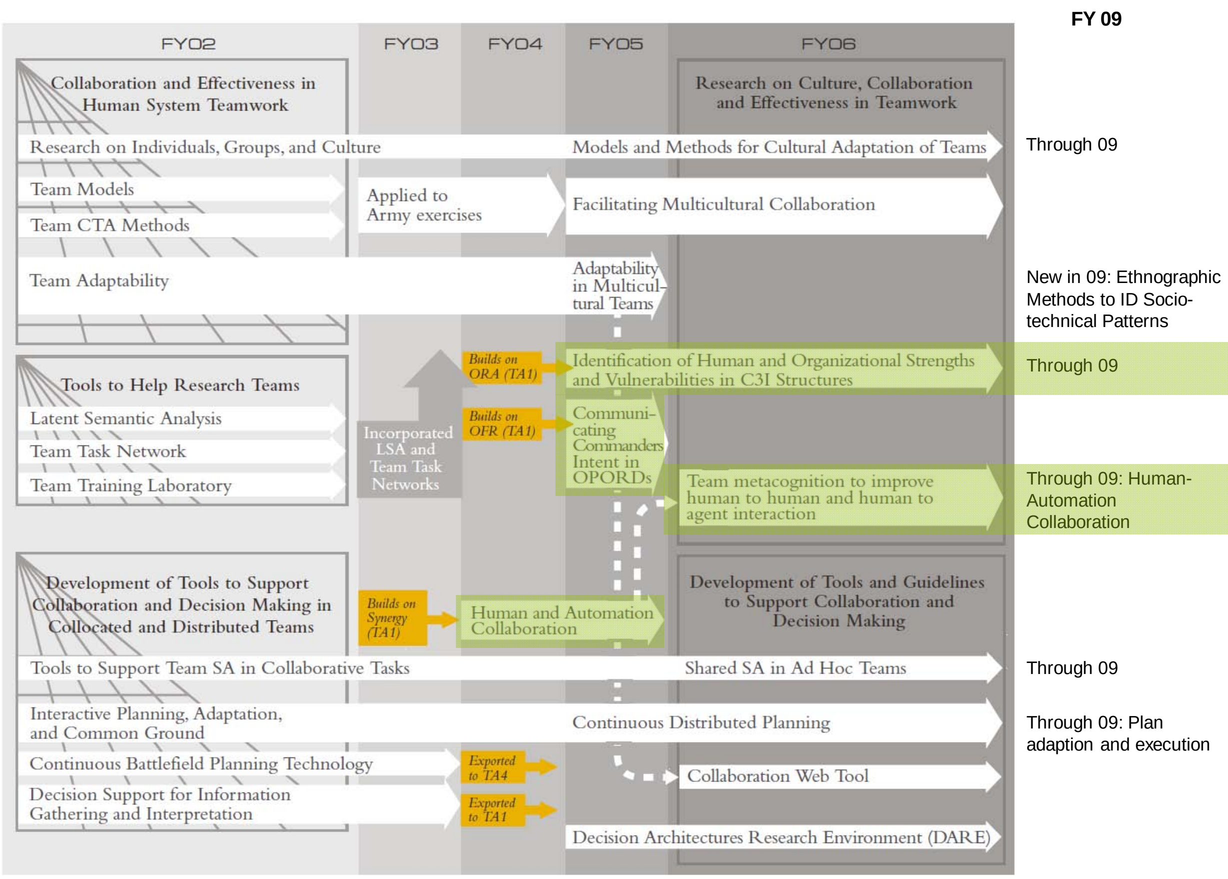

Figure 3- Team Communication and Collaboration

Summary of Research Threads:

- Collaboration and Effectiveness in Human System Teamwork.
- Research on Culture, Colllaboration and Effectiveness in Teamwork.

- Tools to Help Research Teams.
- Development of Tools to Support Collaboration and Decision Making in Collocated and Distributed Teams.
- Development of Tools and Guidelines to Support Collaboration and Decision Making.

1.2.3. Task Area 3: Context-Sensitive Information Presentation (Formerly User-Adaptable Interfaces).

Research objectives:

- Explore ideas, frameworks and technologies to assist Army decision makers in getting the information needed to make sound decisions.
- Allow Soldier to perceive and understand battlefield information without experiencing cognitive overload.

Accomplishments:

- Created haptic displays and guidelines for their use.
- Prototyped adaptive delegation interface to accomplish human supervision of multiple autonomous agents.
- Report documenting how flexible displays can optimally provide dismounted Soldier information requirements.

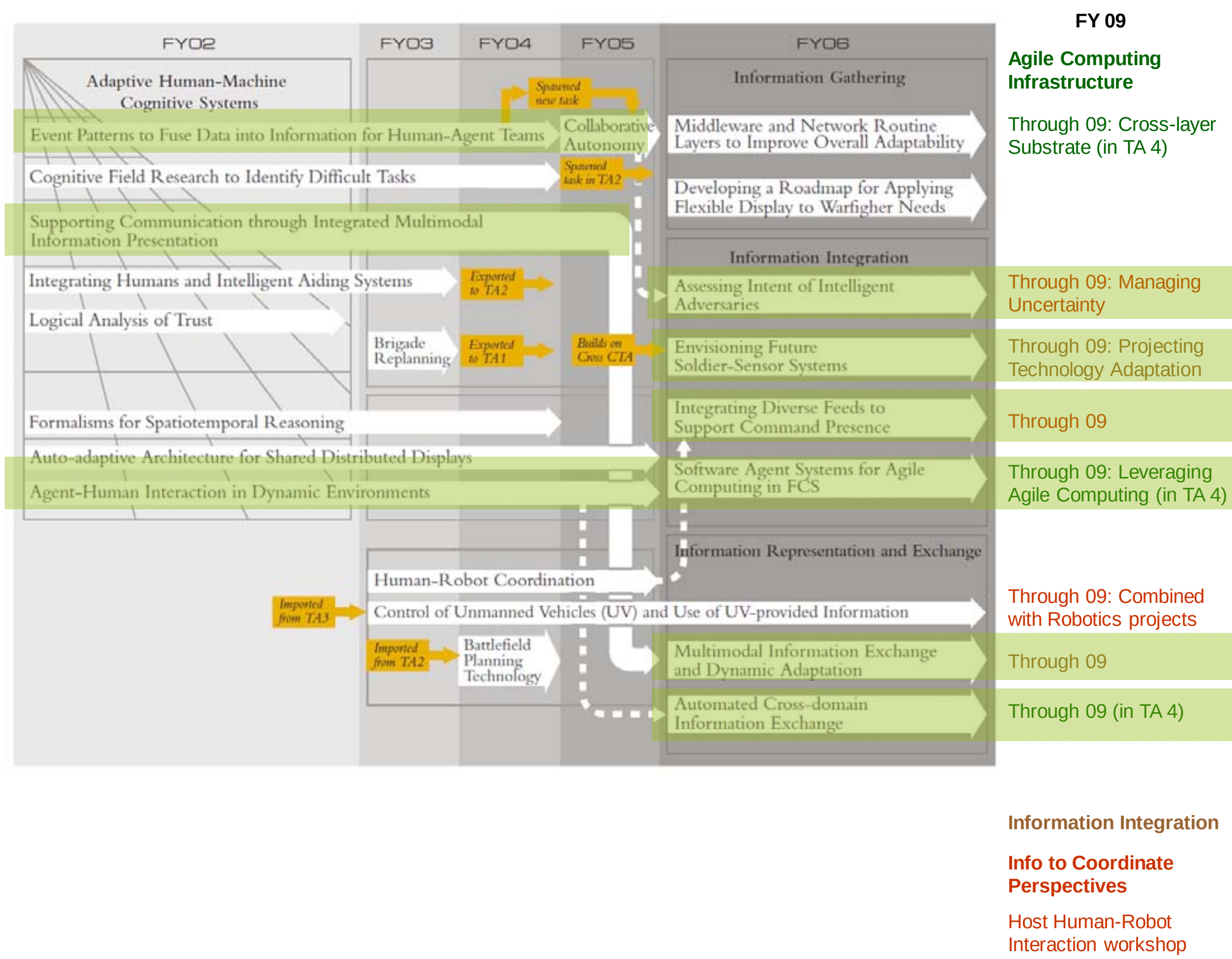

Figure 4- Context Sensitive Information Presentation

Summary of Research Threads:

- Adaptive Human-Machine Cognitive Systems.
- Information Gathering.
- Information Integration.

- Information Representation and Exchange.
- Agile Computing Infrastructure.
- Information Integration.
- Information to Coordinate Perspectives.

1.2.4. Task Area 4: Fusion and Intelligent Architectures (Formerly Auto-Adaptive Interfaces).

Research objectives:

- Explore ideas, frameworks and technologies to assist Army decision makers in getting the information needed to make sound decisions.
- Integrate sophisticated human and machine capabilities while overcoming their limits in:
  - Information gathering.
  - Information integration.
  - Information representation and exchange.

Accomplishments:

- Demonstrated agile software agents on FCS platforms.
- Demonstrated computer reasoning algorithms that address entity re-identification relevant to intelligence analysis systems.
- Conducted experiments to improve appropriate perception of risk in decisions that involve uncertain information (including asset health, status and location).

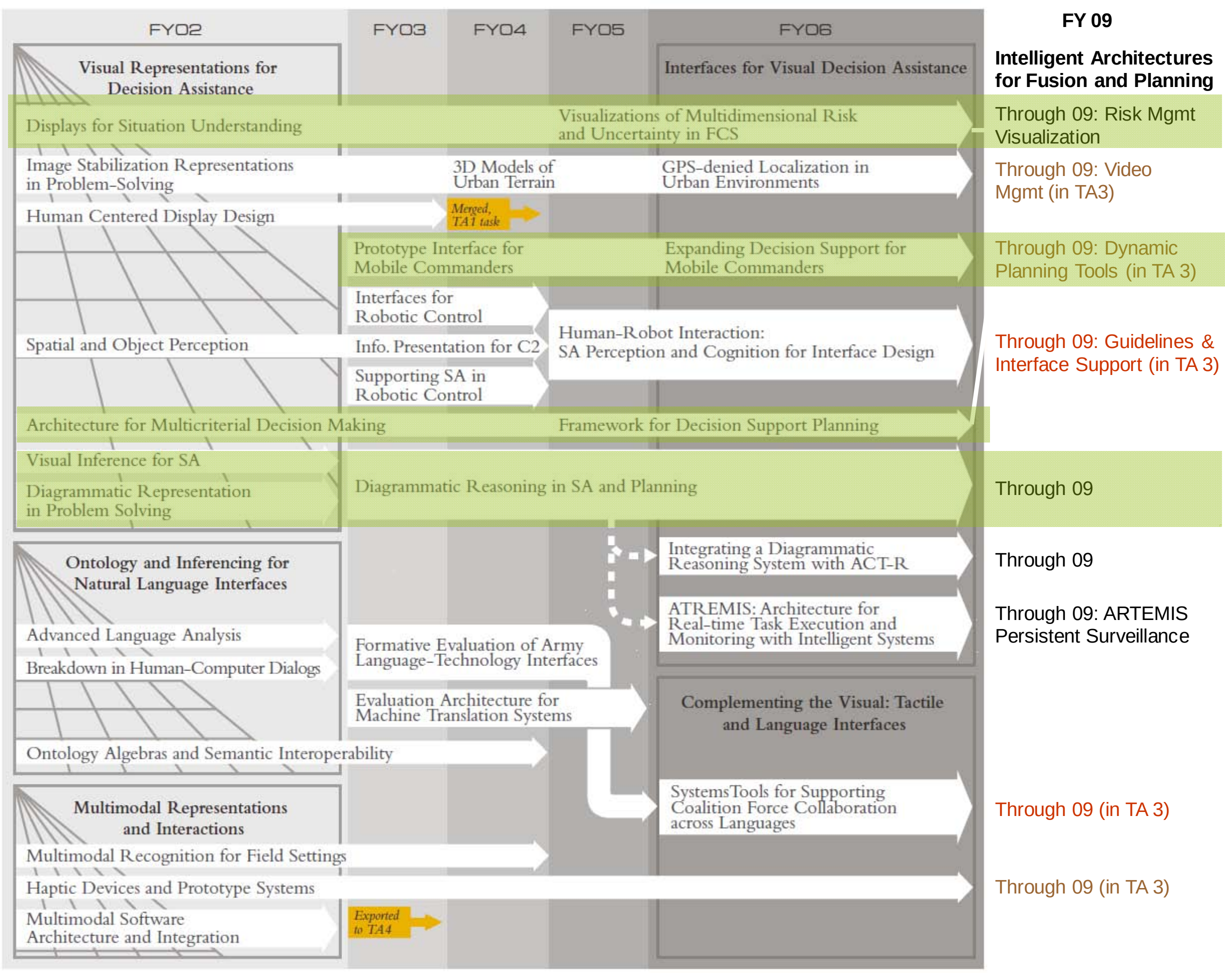

Figure 5- Fusion and Intelligent Architectures

Summary of Research Threads:

- Visual Representations for Decision Assistance.
- Interfaces for Visual Decision Assistance.
- Ontology and Inferencing for Natural language Interfaces.
- Complementing the Visual: Tactile and Language Interfaces.
- Multimodal Representations and Interactions.
- Intelligent Architectures for Fusion and Planning.

1.3. Document Types.

There are 548 study reports from the ADA CTA that are documented in this bibliography. These reports and documents consist of a variety of formats and types. They are:

1.3.1. Published reports from DTIC.

These documents have been published by the originating organization in the appropriate technical report format for that organization and submitted to the DTIC for inclusion in the technical reports national archive. Each of these reports contains a reference to the DTIC control number so it can be accessed by qualified government and other personnel in the archive.

1.3.2. Published reports government agencies.

These documents have been published in a technical report format by the U.S. Army Research Laboratory's Human Research and Engineering Directorate.

1.3.3. Journal Articles.

These are documents published in peer reviewed technical journals and other publications.

1.3.4. Briefings from conference proceedings.

These reports are those presented at professional conferences and published in the proceedings from that conference.

1.3.5. Book Chapters.

These study reports are those published as a chapter in an edited book.

1.3.6. Books.

These study reports are those that resulted in the publishing of a complete book on the subject.

1.4. Report availability.

Most of the documents listed in this bibliography can be obtained from multiple sources. All documents with a DTIC control number can be obtained directly from NTIS either as a PDF document that can be downloaded directly, or in hardcopy form for a processing fee. Reports from the psychology based literature can be obtained from the publication source contained in the report citation.

1.5. How To Use This Bibliography.

This report is designed to facilitate both manual use and automated searches of computer databases.

1.5.1. Using the electronic version of the bibliography.

This report is structured so that it can be effectively used in its hardcopy format but it is designed for optimal use in electronic format. Attached to the back cover of the hardcopy version of the report is a CD containing an electronic copy of this report in a single PDF file. This PDF file supports electronic searches to quickly locate a desired study report using an electronic search of the document.

1.5.2. Using the hardcopy version of the bibliography.

If the PDF version of the bibliography is not available then the reference listings in the hardcopy version of the report can be used to support a manual search for the desired study report(s).

Table: Format of the Annotated Report Listings in this Bibliography

Citation in Human Factors Format: Authors (Year) Title, Publisher, Place of publication

Key Words:
Key words contained in the report. If there were no key words in the report then a listing of categorical keys are listed.

Summary abstract:
The abstract or introduction from the report.

1.6. Distribution Restrictions for this Bibliography.

This document is unclassified and has no distribution restrictions and is authorized for public release as it contains only cited references and abstracts from the study reports listed. However, many of the study reports cited may have associated copyright limitations according to the source of their publication.

2. Listings of Reports in This Bibliography Grouped By Year of Publication.

This section provides a reference listing of all the reports produced by the ADA CTA during the course of the life of the project from 2001 to 2009. There were some reports that were not published until 2010 after the CTA had ended and these are listed in that year group. The reports in each year grouping are in order by the primary author's last name.

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2.1. ADA CTA Study Reports Published in 2001.

Endsley, M. R. (2001). Designing for Situation Awareness in Complex Systems. In Proceedings of Second International Workshop on Symbiosis of Humans, Artifacts and Environment. pp. 176-190. Kyoto, Japan: Program of the Japan Society for the Promotion of Science.

Endsley, M. R., & Jones, D. G. (2001). Disruptions, Interruptions and Information Attack: Impact on Situation Awareness and Decision Making. In Proceedings of 45th Annual Meeting of the Human Factors and Ergonomics Society. Minneapolis, MN (pp. 63-67).

Endsley, M. R., & Jones, D. G. (2001). Disruptions, Interruptions, and Information Attack: Impact on Situation Awareness and Decision Making. In Proceedings of 45th Annual Meeting of the Human Factors and Ergonomics Society. Minneapolis, MN.

Iyer, N. S., & Josephson, J. R. (2001). Multicriterially Best Explanations. In K.P. Jantke and A. Shinohara (Eds.), Discovery Science, Lecture Notes in Artificial Intelligence 2226, Pp. 128-140. Also in Proceedings of Discovery Science 2001: The 4th International Conference on Discovery Science. Washington Dc, 2002. New York, NY: Springer Verlag. ISBN 3-540-42956-5.

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Riley, J. M., & Kaber, D. B. (2001). Utility of Situation Awareness and Attention for Describing Telepresence Experiences in a Virtual Teloperation Task. In Proceedings of International Conference on Computer-Aided Ergonomics and Safety.

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Warwick, W., & Archer, S. (2001). Incorporating Aspects of Human Decision Making in Task Network Simulation Tools. In Proceedings of 2001 NATO RTA Conference on Future Modeling and Simulation Challenges. Breda, Breda, Netherlands, 12-14 November 2001, and published in RTO-MP-073.

Woods, D., & Christoffersen, K. (2001). Balancing Practice-Centered Research and Design. In M.D. McNeese and M.A. Vidulich (Eds.), Cognitive Systems Engineering in Military Aviation Domains, Pp. 121-136. Wright-Patterson AFB, OH: Human Systems Information Analysis Center (HSIAC).

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Allsopp, D. N., Bradshaw, J. M., Suri, N., Durfee, E. H., Knoblock, C. A., Tate, A., & Thompson, C. W. (2002). Coalition Agents Experiment: Multiagent Cooperation in International Coalitions. Special Issue on Knowledge Systems for Coalition Operations. IEEE Intelligent Systems, 17(3), 26-35.

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3. The Annotated Bibliography.

This section is the main body of this report. All of the reports listed are in order by primary author.

Agrawal, A., Meth, R., & Chellappa, R. (2005). Hierarchical DEM Refinement Using Surface Parallax. In Proceedings of 24th Army Science Conference. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
We present a multi-resolution approach to update and refine coarse 3D models of urban environments from a sequence of intensity images using surface parallax. A coarse and potentially incomplete depth map of the scene obtained from a Digital Elevation Map (DEM) is used as a reference surface which is refined and updated using this approach. We first estimate the camera motion using the reference depth map. Using the estimated camera motion, at each level in the multi-resolution framework, motion of 3D points on the reference surface is compensated, and the residual flow field, which is an epipolar field, is estimated and used to refine the depth map at that level. At a coarse resolution, the difference between the reference depth and the true depth will be small, leading to a small parallax field. The refined depth map from the coarser level is then propagated to the finer level and is used as a reference depth map at that level. Thus, significant deviations of an available model from a true model can be handled using this approach.

Agrawal, A., & Chellappa, R. (2005). Moving Object Segmentation and Dynamic Scene Reconstruction Using Two Frames. In In Proceedings of IEEE International Conference on Acoustics, Speech, and Signal Processing. (Winner of student paper award.).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
We present an iterative algorithm for segmenting independently moving objects and refining and updating a coarse depth map of the scene under unconstrained camera motion (translation and rotation) with the assumption that the independently moving objects undergoes pure translation. Given a coarse depth map acquired by a range-finder or extracted from a Digital Elevation Map (DEM), the ego-motion is estimated by combining a global ego-motion constraint and a local brightness constancy constraint using least median of squares (LMedS) which treats independently moving objects as outliers. Using the estimated camera motion and the available depth estimate, motion of the 3D points is compensated. We utilize the fact that the resulting surface parallax field is an epipolar field and use a corresponding parametric model to estimate the parallax vectors for all pixels. We use the previous motion estimate to get the epipolar direction and hence pixels where the parallax direction is not aligned towards the epipolar direction are segmented out as moving points. The depth map for static pixels is refined using the estimated parallax vectors. All segmented regions are removed for robustly estimating the ego-motion in subsequent iterations. A parametric flow model is fitted to the segmented regions and their 3D motion is estimated using subspace analysis. We present experimental results using both synthetic and real data to validate the effectiveness of the proposed algorithm.

Agrawal, A., & Chellappa, R. (2005). Robust Ego-Motion Estimation and 3D Model Refinement in Scenes with Varying Illumination. In In Proceedings of IEEE Computer Society Workshop on Motion and Video Computing.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
We present an iterative algorithm for robustly estimating the ego-motion and refining and updating a coarse depth map using surface parallax and a generalized dynamic image (GDI) model. Given a coarse depth map acquired by a

range-finder or extracted from a Digital Elevation Map (DEM), we first estimate the ego-motion by combining a global ego-motion constraint and a local GDI model. Using the estimated camera motion and the available depth estimate, motion of the 3D points is compensated. We utilize the fact that the resulting surface parallax field is an epipolar field and constrain its direction using the previous motion estimates. We then estimate the magnitude of the parallax field and the GDI model parameters locally and use them to refine the depth map estimates. We use a tensor based approach to formulate the depth refinement procedure as an eigen-value problem and obtain confidence measures for determining the accuracy of the estimated depth values. These confidence measures are used to remove regions with potentially incorrect depth estimates for robustly estimating ego-motion in the next iteration. Experimental results using both synthetic and real data are presented. Comparisons with results obtained using a brightness constancy (BC) model show that the proposed algorithm works significantly better when time-varying illumination changes are present in the scene.

Agrawal, A., & Chellappa, R. (2005). Robust Ego-Motion Estimation and 3D Model Refinement Using Depth Based Parallax Model. In In Proceedings of IEEE International Conference on Image Processing.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
We present an iterative algorithm for robustly estimating the egomotion and refining and updating a coarse. noisy and partial depth map using a depth based parallax model and brightness derivatives extracted frnm an image pair. Given a coarse, noisy and partial depth map acquired by a range-tinder or obtained from a Digital Elevation Map (DEM), we first estimate the ego-motion by combining a global ego-motion constraint and a local brightness constancy constraint. Using the estimated camera motion and the available depth map estimate, motion of the 3D points is compensated. We utilize the fact that the resulting surface parallax field is an epipolar field and knowing its direction from the previous motion estimates, estimate its magnitude and use it to refine the depth map estimate. Instead of assuming a smooth parallax field or locally smooth depth models, we locally model the parallax magnitude using the depth map, formulate the problem as a generalized eigen-value analysis and ohtain better results.

In addition, confidence measures for depth estimates are provided which can he used to remove regions with potentially incorrect (and outliers in)
depth estimates for robustly estimating ego-motion in the next iteration. Results on both synthetic and real examples are presented.

Agrawal, A., & Chellappa, R. (2006). Fusing Depth and Video Using Rao-Blackwellized Particle Filter. In In Proceedings of First International Conference on Pattern Recognition and Machine Intelligence, Kolkata, India.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
We address the problem of fusing sparse and noisy depth data obtained from a range finder with features obtained from intensity images to estimate ego-motion and refine 3D structure of a scene using a Rao-Blackwellized particle ¯lter. For scenes with low depth variability, the algorithm shows an alternate way of performing Structure from Mo-tion (SfM) starting with a °at depth map. Instead of using 3D depths, we formulate the problem using 2D image domain parallax and show that conditioned on non-linear motion parameters, the parallax magni-tude with respect to the projection of the vanishing point forms a linear subsystem independent of camera motion and their distributions can be analytically integrated. Thus, the structure is obtained by estimating parallax with respect to the given depths using a Kalman filter and only the ego-motion is estimated using a particle filter. Hence, the required number of particles becomes independent of the number of feature points which is an improvement over previous algorithms. Experimental results on both synthetic and real data show the e®ectiveness of our approach.

Agrawal, A., & Chellappa, R. (2006). Robust Ego-Motion Estimaton and 3D Model Refinement Using Surface Parallax. IEEE Transactions on Image Processing, May 2006, 15(5), 1215 - 1225.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Direct methods, surface parallax, three-dimensional (3-D) modeling.

Summary abstract:
We present an iterative algorithm for robustly estimating the ego-motion and refining and updating a coarse depth map using parametric surface parallax models and brightness derivatives extracted from an image pair. Given a coarse depth map acquired by a range-finder or extracted from a digital elevation map (DEM), ego-motion is estimated by combining a global ego-motion constraint and a local brightness constancy constraint. Using the estimated camera motion and the available depth estimate, motion of the three-dimensional (3-D) points is compensated. We utilize the fact that the resulting surface parallax field is an epipolar field, and knowing its direction from the previous motion estimates, estimate its magnitude and use it to refine the depth map estimate. The parallax magnitude is estimated using a constant parallax model (CPM) which assumes a smooth parallax field and a depth based parallax model (DBPM), which models the parallax magnitude using the given depth map. We obtain confidence measures for determining the accuracy of the estimated depth values which are used to remove regions with potentially incorrect depth estimates for robustly estimating ego-motion in subsequent iterations. Experimental results using both synthetic and real data (both indoor and outdoor sequences) illustrate the effectiveness of the proposed algorithm.

Agrawal, A., Raskar, R., & Chellappa, R. (2006). Edge Suppression by Gradient Field Transformation Using Cross-Projection Tensors. In In Proceedings of the 2006 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'06).

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Conference Proceedings

Summary abstract:
We propose a new technique for edge-suppressing operations on images. We introduce cross projection tensors to achieve affine transformations of gradient fields. We use these tensors, for example, to remove edges in one image based on the edge-information in a second image. Traditionally, edge suppression is achieved by setting image gradients to zero based on thresholds. A common application is in the Retinex problem, where the illumination map is recovered by suppressing the reflectance edges, assuming it is slowly varying.
We present a class of problems where edge-suppression can be a useful tool. These problems involve analyzing images of the same scene under variable illumination. Instead of resetting gradients, the key idea in our approach is to derive local tensors using one image and to transform the gradient field of another image using them. Reconstructed image from the modified gradient field shows suppressed edges or textures at the corresponding locations. All operations are local and our approach does not require any global analysis.
We demonstrate the algorithm in the context of several applications such as (a) recovering the foreground layer under varying illumination, (b) estimating intrinsic images in non-Lambertian scenes, (c) removing shadows from color images and obtaining the illumination map, and (d) removing glass reflections.

Agrawal, A., Raskar, R., & Chellappa, R. (2006). What Is the Range of Surface Reconstructions from a Gradient Field? In In Proceedings of 9th European Conference on Computer Vision. Austria, Graz.

Key Words:

An Annotated Bibliography of Studies and Reports Produced by the Advanced Decision Architectures Consortium of the Collaborative Technology Alliance from 2001 to 2010

ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The psychology of remote-operator environmental awareness is an important area of inquiry in which recent advances enable improved deployment of robotic vehicles. The use of unmanned ground vehicles (UGVs) allows for remote sensing and action in hazardous environments at a safe distance. Proponents of UGV deployment for both military and civilian applications must overcome technical challenges faced in realizing their full potential. The development of operationally effective UGVs remains demanding due to the complexity of autonomous ground navigation and the cognitive requirements on human operators. These difficulties appear across a variety of UGV applications, including the use of large autonomous vehicles for reconnaissance or convoy operations and the deployment of small remotely operated vehicles for explosives disposal or urban search-and-rescue tasks.

Agrawal, A. K., & Chellappa, R. (2004). 3D Model Refinement Using Surface-Parallax. IEEE Acoustics, Speech, and Signal Processing, (Vol. 3), pp. 285-288. Presented at ICASSP 2004. Montreal, Canada.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
We present an approach to update and refine coarse 3D models of urban environments from a sequence of intensity images using surface parallax. This generalizes the plane-parallax recovery methods to surface-parallax using arbitrary surfaces. A coarse and potentially incomplete depth map of the scene obtained from a Digital Elevation Map (DEM) is used as a reference surface which is refined and updated using this approach. The reference depth map is used to estimate the camera motion and the motion of the 3D points on the reference surface is compensated. The resulting parallax, which is an epipolar field, is estimated using an adaptive windowing technique and used to obtain the refined depth map.

Agrawal, A. K., Meth, R., & Chellappa, R. (2004). Surface Parallax Based Hierarchical Approach for Model Refinement (Hierarchical DEM Refinement Using Surface Parallax). In In Proceedings of 2004 ICPR. Cambridge, UK. DTIC ADA431639.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Fields and Groups:
080200 - Cartography and Aerial Photography
Descriptors:
(U) *DIGITAL MAPS, SYMPOSIA, THREE DIMENSIONAL, FLOW FIELDS, ELEVATION, URBAN AREAS, DIGITAL CAMERAS
Identifiers:
(U) COMPONENTS REPORTS

Summary abstract:
We present a multi-resolution approach to update and refine coarse 3D models of urban environments from a sequence of intensity images using surface parallax. A coarse and potentially incomplete depth map of the scene obtained from a Digital Elevation Map (DEM) is used as a reference surface which is refined and updated using this approach. We first estimate the camera motion using the reference depth map. Using the estimated camera motion, at each level in the multiresolution framework, motion of 3D points on the reference surface is compensated, and the residual flow field, which is an epipolar field, is estimated and used to refine the depth map at that level. At a coarse resolution, the difference between the reference depth and the true depth will be small, leading to a small parallax field. The refined depth map from the coarser level is the propagated to the finer level. Thus, significant deviations of an available model from a true model can be handled using this approach.

Agrawal, A. K., Shekhar, C., David, P., & DeHart, J. (2003). Mapping Ground Video to Aerial Dem's. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making
Digital Elevation Map, Mobile Robot, Video, Registration, Depth Map, Simulated Annealing, Simplex algorithm, Hausdorff Distance, Color Segmentation

Summary abstract:
We present an approach for registering an aerial Digital Elevation Model (DEM) with a color intensity image obtained using a camera mounted on a mobile robot. An approximate measurement of the camera pose is obtained using auxiliary sensors on-board the robot. The DEM is transformed into a depth map in the camera's coordinate system using this initial pose. The problem is now simplified to the alignment of two images, one containing intensity information, and the other, depth. Region boundaries in the intensity image are matched with discontinuities in the depth map using a robust directed Hausdorff distance. This cost function is minimized with respect to the six parameters defining the camera pose. Due to the highly non-linear nature of cost function with multiple local minima, a stochastic algorithm based on the downhill simplex principle is employed for minimization. Results on real data are presented.

Allender, L. (2010). Chapter 17. A Cognitive Systems Engineering Approach for Human-Robot Interaction: Lessons from an Examination of Temporal Latency. In M. Barnes and F. Jentsch (Eds.), Human-Robot Interactions in Future Military Operations: Ashgate Publishing, Inc.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Advanced robotics technology holds promise for extending, enhancing, even replacing humans in the performance of dangerous or tedious tasks. Search and rescue robots can go where humans cannot-or dare not-and become remote eyes and ears for human first responders and rescue teams (Casper & Murphy, 2003). Robots that provide some level of care or supervision in medical contexts are being tested and are intended to enhance the well being of the person being cared for as well as lightening the loads of other care-providers (e.g., Gockley & Matari6, 2006). Robots are even being evaluated in social and educational settings with children to understand the development, or evolution, of naturalistic human robot interaction (e.g., Tanaka et aI., 2006). Of course, robots may also be fun, such as the cocktail-serving robots offered in the 2003 Neiman Marcus Christmas catalog.

Allender, L., McDermott, P. L., Luck, J., & Fisher, A. (2006). Team Communication with and without Aids for Transmitting Remote Information. In In Proceedings of 50th Annual Meeting of the Human Factors and Ergonomics Society, San Francisco, CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The introduction of unmanned vehicles (UVs) and real-time electronic information presentation to military teams is intended to keep Soldiers safe and enable more effective performance. Two game-based experiments were conducted in which teams conducted a time-limited "Black Hawk Down" rescue mission with and without UV-

provided information. When UV information was available, it was relayed between team members in face-to-face communication or remotely, with or without electronic maps, and with or without video images from the UV. Three types of analyses were performed. The communication content of the verbal protocol was analyzed and the use of information display technologies and employment of strategies was tabulated. The verbal protocol analyses revealed the push/pull of team communication and common confusions. Results of the technology use and strategy assessment form the basis for recommendations for display design and recommended practice for the use of such technologies in the field.

Allsopp, D., Beautement, P., Kirton, M., Bradshaw, J. M., Suri, N., Tate, A., & Burstein, M. (2003). The Coalition Agents Experiment: Network-Enabled Coalition Operations. Special Issue on Network-enabled Capabilities, Journal of Defence Science, 8(3), 130-141.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Multinational coalitions are increasingly important in military operations. But coalitions today suffer from heterogeneous command systems, labour-intensive information collection and coordination, and different and incompatible ways of representing information. The purpose of Network Enabled Capability (NEC) is to enhance military capability by exploiting information better. The Coalition Agents Experiment (CoAX) was an international collaborative research effort to examine how the emerging technologies of software agents and the semantic web could help to construct coherent command support systems for coalition operations. Technology demonstrations based on a realistic coalition scenario showed how agents and associated technologies facilitated run-time interoperability across the coalition, responded well to unexpected battlespace events, and aided the selective sharing of information between coalition partners. We describe the CoAX experiments, the approaches and technologies used, and highlight how they support the NEC concept. CoAX produced a prototype “Coalition agents starter pack” that could be developed further to support coalition warfare.

Allsopp, D. N., Bradshaw, J. M., Suri, N., Durfee, E. H., Knoblock, C. A., Tate, A., & Thompson, C. W. (2002). Coalition Agents Experiment: Multiagent Cooperation in International Coalitions. Special Issue on Knowledge Systems for Coalition Operations. IEEE Intelligent Systems, 17(3), 26-35.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Military success requires executing high-tempo, coherent, decisive actions faster than an opponent can react—that is, decision dominance through command agility. Command agility means having the flexibility to grasp fleeting opportunities and being innovative, creative, and unpredictable in a manner that (even if low-tempo) increases confusion in the opponent’s mind. This process is command-led, with human decision making primary and technology playing a secondary role. Shared understanding and information superiority are key enablers in this process and are fundamental to network-centric warfare (www.dodccrp.org). In addressing interoperability requirements, we must also address data security, control over semitrusted software from other coalition partners, and the resulting system’s robustness—for example, its ability to withstand denial-of-service attacks.
However, good decisions depend on good data, which can become a problem as mission complexity increases. Military coalitions—large-scale, multifaceted, multinational, virtual organizations—often must be rapidly created and changed as circumstances shift. In addition to integrating single-service and joint capabilities into a coherent force, coalition operations must rapidly configure foreign or legacy systems into a cohesive whole. Yet current

coalition operations often suffer from data overload, information starvation, laborintensive information collection and coordination, and stand-alone stovepipe command systems that use incompatible data formats. This leads to a horrendous technical integration task and offers commanders only scattered snapshots of the battlespace.
In the inevitable absence of preexisting coordinated systems, we must take a rapid, flexible, on-the-fly approach that permits assembling capabilities at runtime. We believe agent-based computing (described in the sidebar, "Software Agent Technology") offers a promising new approach to effective coalition operations because it embraces the coalition environment's open, heterogeneous, diverse, dispersed nature. This article describes how software agents acting on behalf of human users enable military commanders to act decisively in cyberspace and thus contribute to "cyberspace superiority," a critical component of warfare in the information age.1 We focus here on the rapid integration of agents and legacy systems to improve interoperability and support human situational awareness and decision making, rather than, for example, sophisticated teamwork and planning between agents.2

Anders, S., Patterson, E. S., Woods, D. D., & Ebright, P. R. (2007). Projecting Trajectories for a New Technology Based on Cognitive Task Analysis and Archetypal Patterns: The Electronic Icu. In In Proceedings of K.Mosier & U. Fischer (eds.), Proceedings of the Eighth International Conference on Naturalistic Decision Making.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Ethnographic observation, cognitive task analysis, S-curve for technology adoption, electronic ICU, healthcare, anomaly response, complexity

Summary abstract:
In many cases, cognitive task analysis (CTA) methods are used to identify patterns in how expert practitioners interact with computerized support to achieve domain-specific objectives. A CTA rarely makes explicit projections about potential trajectories of adaptation through use that may occur over the longer term. Studies of technology change consider such trajectories of change and adaptation as new systems and capabilities are introduced and mature. One model of potential trajectories of change is depicted by the so-called "S-curve" for diffusion of innovation, where new technologies are adopted early by more educated users with higher propensity to accept risk ("innovators"), followed by accelerated adoption for the majority of users, and a slower adoption pace by less educated, risk-averse users ("laggards"). We suggest that the Naturalistic Decision Making (NDM) research base may be sufficient to offer useful alternatives to the S-curve model. We illustrate the proposed approach with a telemedicine example: the electronic Intensive Care Unit (e-ICU). Based upon "bootstrapping" interviews and 40 hours of direct observation in one e-ICU, we describe three functions of the technology as it is currently used: 1) anomaly response, 2) access to specialized expertise, and 3) sensemaking. We discuss how explicit projections may support steering technology design and implementation in more productive directions, and how we might manage negative "side effects" associated with particular trajectories by addressing these as post-conditions to be met as new devices or systems move toward realization. We conclude that the ability to project possible trajectories in order to aid in selecting among alternatives and managing post-conditions of change can be done based on the pattern base built up through NDM work. Useful CTAs should have the ability to make explicit trajectory projections and identify post-conditions.

Anders, S., Zelik, D., Jacoby, T., Patterson, E. S., & Woods, D. D. (2007). Exploring Challenges of Information Dynamics Using an Animock. In In Proceedings of 51st Annual Meeting of the Human Factors and Ergonomics Society. Baltimore, MD.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In this paper, we describe the use of an animated prototyping technique to elicit feedback on the usefulness of a set of modular design concepts for dealing with information dynamics in inferential analysis under data overload conditions. The design concepts were comprised of innovative solutions that utilized technology to assist in inferential analysis. The findings generally support the "promisingness" of the design directions for addressing information dynamics challenges in inferential analysis under data overload. Elicited feedback provides insight on

how the concepts might prove useful to intelligence analysts in the field. Analysts recommended significant modifications that would be difficult to change post-implementation of software, suggesting that the animock technique was useful for exploring how design concepts could address challenging issues where no current software support exists.
In this paper, we describe the use of an animated prototyping technique, so-called animocks (Roesler et al., 2005), to explore the usefulness of design concepts to address information dynamics challenges. Specifically, an animock was used in 2.5 hour focus group elicitation sessions at two intelligence agencies. The animock illlustrated a set of modular design concepts, or “design seeds” (Woods, 1998; cf., Patterson et al., 2001), that covered the three high-level cognitive functions in inferential analysis: down collect, conflict and corroboration, and hypothesis exploration (Elm et al., 2005). The animock is a dynamic storyboarding technique that represents a potential envisioned world. In the current paper researchers present the concepts, findings from the focus groups, and discuss the use of animocks for eliciting information about envisioned support tools for particularly challenging problems where no current software support exists.

Archer, R., Lebiere, C., Warwick, W., Schunk, D. W., & Biefeld, E. (2003). Integration of Task Network and Cognitive Models to Support System Design. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making

Summary abstract:
This paper describes the integration of the IMPRINT task network modeling tool with the ACT-R cognitive architecture. The resulting system was used to model the interaction between an operator and an interface controlling the Demo III robotic vehicle. IMPRINT was used to represent the state of the vehicle and the control interface while ACT-R modeled the cognitive state of the operator. The combined model was used to evaluate the design of the interface and especially the occurrence of errors. The model produced a wide range of cognitive errors, and made suggestions for design changes that could help reduce their occurrence.

Archer, S., Archer, R., & Matessa, M. (2007). Our GRBIL Has a Split Personality. In In Proceedings of 2007 Digital Human Modeling for Design and Engineering Conference, SAE International, Seattle, WA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
DEFINITIONS, ACRONYMS, ABBREVIATIONS
OCU: Operator Control Unit
ACT -R: Adaptive Control of Thought - Rational
VTI: Vetronics Technology Integration
ARL: Army Research laboratory
WYSIWYG: What you see is what you get
GRBll: Graph-Based Interface language

Summary abstract:
Developers of future systems are relying on graphical user interfaces (GUI) for user interaction. As the interfaces get more powerful and complex, it becomes increasingly important to be able to predict how well they will work prior to absorbing the cost of implementation. This paper describes the development, application, and future plans for the Graph-Based Interface language (GRBll) tool. GRBll can be used to predict human performance on new GUI designs, resulting in quantitative comparisons between interface alternatives. This enables human factors engineers to participate in system design processes and achieve influence very early. Using GRBll, an interface designer can sketch the proposed interfaces, describe the tasks that the user wiU perform, and even inject stressor effects to represent fatigued or under-trained users. GRBll will generate estimates for the times to perform the tasks and will predict whether errors (such as those caused by memory lapses) are likely. The designer can then use GRBll to adjust the GUI to explore alternatives that might improve performance.

Arguedas, M., Perez, C., Carvalho, M., Granados, A., Hobakc, K., Kraus, W. (2009). Investigating the Use of Topology Adaptation for Robust Multi-Path Transport: A Preliminary Study. In In Proceedings of 8th IEEE International Symposium on Network Computing and Applications, NCA 09, Boston, July 9-11, 2009.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In this paper we introduce a topology control algorithm for increasing transport robustness and efficiency by creating two simultaneous communication paths between the source and destination nodes of a data flow. We make use of a cross-layer substrate that allows us to detect the flows of data in the network while also providing finer control of the routing. Because information of flow traffic in the network is available, the algorithm attempts to achieve intra-flow interference reduction by exploiting node mobility.

Banerjee, B. (2003). A Self-Organizing Auto-Associative Network for the Generalized Physical Design of Microstrip Patches. IEEE Transactions on Antennas & Propagation, 51(6), 1301-1306.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Hopfield-like optimization network, information extracting self-organizing neural network (IESONN), patch antenna.

Summary abstract:
The current work deals with the efficient physical design of patch antennas given the desired parameters like resonant frequency , feed point position , substrate thickness , relative permittivity e sub v, input impedance (Z (=R + jX), and efficiency . Based loosely on the analogy of perception of the human brain, a neurocomputing network has been designed, consisting of two distinct phases, namely, the training phase and the application phase. The training phase accepts as input the exhaustive set of the said parameters for patches of different shapes and sizes and determines the optimized processors (processors that adequately define the information topology of the input data set) from the exhaustive training instances using a set of information extracting self-organizing neural networks. The outputs of the training phase are sets of processors, being the number of different shapes of patches taken into consideration. The application phase determines the shape and size of a microstrip antenna when its desired parameters are presented to the network as the external input. This is achieved by comparing the external input with each set of processors, hence determining the cost due to each comparison. A cost matrix is thus formed which when passed through an optimization network gives the best match and hence the shape and shape determining attributes of the patch whose parameters had been passed as external input.

Banerjee, B. (2004). Recognition of Partially Occluded Shapes Using a Neural Optimization Network. Machine Graphics & Vision Journal, Institute of Computer Science of the Polish Academy of Sciences, 13(1/2), 3-23.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
occlusion, angle coding, continuous Hopfield network, cost function, Liapunov energy function

Summary abstract:

The current work presents an algorithm for recognition of partially occluded shapes in a cluttered scene. The imates are represented by a sequence of angles subtended at the corner points. The cost due to comparison between the input cluttered scene and the stored images is obtained from a cost function designed to score the obtained information in the form of a cost matrix which is presented to the input of an optimization network. The parameters of the optimization network are determined so as to minimize an energy function, the minima of which occur at the solutions of the problem. The results, as obtained in different domains (2D shapes and projected 3D shapes) with different degrees of occlusion, provide interesting insights into the operation of the algorithm as well as avenues for future research.

Banerjee, B., & Chandrasekaran, B. (2005). Perceptual and Action Routines in Diagrammatic Reasoning for Entity-Reidentification. In In Proceedings of 24th Army Science Conference. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The Objective Force requirements of responsiveness, agility and versatility call for digitized graphical decision support interfaces that automate or otherwise help in various reasoning tasks, including reasoning with visual and diagrammatic representations that are ubiquitous in Army situation understanding, planning and plan monitoring. In earlier papers, we described a diagrammatic reasoning architecture, and demonstrated the approach for instances of maneuver recognition and information fusion for entity-reidentification problems. The current paper characterizes the computational properties of the core perception and path-finding algorithms that are an important part of the technology's application for a class of fusion problems. This analysis is important since the practicality of automating diagrammatic reasoning for Army applications depends on developing algorithms with manageable complexity.

Banerjee, B. (2006). A Layered Abductive Inference Framework for Diagramming Group Motions. Logic Jnl IGPL, Oxford University Press, 2006, 14(2): 363-378.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
layered abduction, diagram, group motion.

Summary abstract:
Many events in different domains are characterized by a large number of individual moving elements, either in pursuit of a goal in groups (as in military operations), or subject to underlying physical forces that group elements with similar motion (as in weather phenomena). Visualizing and reasoning about happenings in such domains are often facilitated by abstracting the mass of spatiotemporal data into spatial diagrams of group motions, and overlaying them on abstractions of static features, like maps. The standard approach has been to use a clustering algorithm to group the entities and extract their motions, which often produces unsatisfactory results when the data is noisy and incomplete. In this paper, we present for the task a multilayered abductive inference framework where hypotheses largely flow upwards from raw data to a diagram, but there is also a top-down control that asks lower levels to supply alternatives if the higher level hypotheses are not d""emed sufficiently coherent. This top-down-bottom-up interplay to combine numerical clustering algorithms with symbolic knowledge about consistency models the flexibility of human reasoning in "uch tasks that enables the framework to successfully deal with extremely noisy and incomplete data. We present experimental results as obtained by deploying the proposed framework and discuss several issues related to construction of such diagrams, from data sets over a few days of a large number of military units engaged in exercises at the National Technical Center, California, USA.

Banerjee, B. (2007). String Tightening as a Self-Organizing Phenomenon. IEEE Transactions on Neural Networks, Vol 18, No 5., 18(5), 1463-1471.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Convex hull, homotopy, neural network,
self-organization, shortest path, smooth path, tighten string.

Summary abstract:
Abstract—The phenomenon of self-organization has been of special interest to the neural network community throughout the last couple of decades. In this paper, we study a variant of the self-organizing map (SOM) that models the phenomenon of self-organization of the particles forming a string when the string is tightened from one or both of its ends. The proposed variant, called the string tightening self-organizing neural network (STON), can be used to solve certain practical problems, such as computation of shortest homotopic paths, smoothing paths to avoid sharp turns, computation of convex hull, etc. These problems are of considerable interest in computational geometry, robotics path-planning, artificial intelligence (AI) (diagrammatic reasoning), very large scale integration (VLSI) routing, and geographical information systems. Given a set of obstacles and a string with two fixed terminal points in a 2-D space, the STON model continuously tightens the given string until the unique shortest configuration in terms of the Euclidean metric is reached. The STON minimizes the total length of a string on convergence by dynamically creating and selecting feature vectors in a competitive manner. Proof of correctness of this anytime algorithm and experimental results obtained by its deployment have been presented in the paper.

Banerjee, B., & Chandrasekaran, B. (2006). Constructing Diagrams Representing Group Motions. In A. Blackwell, K. Marriott, & A. Shimojima (Eds.), Diagrammatic Reasoning and Inference. Lecture Notes in Artificial Intelligence (pp. 376-378). 2980, Berlin: Springer Verlag.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Certain domains, such as military activities and weather phenomena, are characterized by a large number of individual elements moving in a field, either in pursuit of an organized activity in groups at different levels of aggregation (military action), or subject to underlying physical forces that cluster different elements in different groups with common motion (weather). Reasoning about phenomena in such domains is often facilitated by abstracting the mass of data into diagrams of motions of groups, and overlaying them on diagrams that abstract static features into regions and curves. Constructing such diagrams of motion basically calls for clustering at different time instants and joining the centers of the clusters to produce lines of motion. However, because of incompleteness and noisiness of data, the best that can be done is to produce plausible hypotheses. We envision a multi-layered abductive inference approach in which hypotheses largely flow upwards from raw data to a diagram to be used by a problem solver, but there is also a top -down control that asks lower levels to supply alternatives if the original hypotheses are not deemed sufficiently coherent.

Banerjee, B., & Chandrasekaran, B. (2006). A Spatial Constraint Satisfaction Framework for Synthesizing Perceptions and Actions in Diagrammatic Reasoning. In In Proceedings of 1st International Workshop on Constraint Programming for Graphical Applications. In conjunction with 12th International Conference on Principles and Practice of Constraint Programming, Nantes, France.

Key Words:

ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Diagrammatic reasoning is often modeled as a process in which subtasks may be solved, as appropriate, either by inference from symbolic representations or by information extracted by perception from a diagram, and additional subtasks may create or modify objects in the diagram. The required perceptions and actions are defined in terms of properties and relations to be satisfied by a set of diagrammatic objects. Performing such perceptions and actions in general requires visual problem solving for humans. This paper investigates the use of spatial constraint satisfaction for automatically synthesizing solutions for per- ceptions and actions. Our research goal is to develop a high-level language that is finite, extensible, human-usable, and expressive enough to describe the properties of desired perceptions and actions as constraints specified in terms of well-defined mathematical/logical functions and predefined perceptions/actions; to compute the solutions of the desired perceptions/actions and diagrammatically represent the outcome for actions; and to automatically synthesize their programs, thereby transforming them into readily executable routines. The ideas are illustrated by several examples in different domains.

Banerjee, B., & Chandrasekaran, B. (2006). Synthesizing Visual and Action Routines Using Constraint Programming. In In Proceedings of International Conference on Diagrammatic Representations and Reasoning at Stanford University.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
A diagrammatic problem-solver requires a library of visual routines (VRs) and action routines (ARs) - the VRs are used to obtain information of specified types from the diagram and ARs to modify the diagram in specified ways. The VRs/ARs required are unbounded - a new domain may call for new perceptions and actions. We report on progress on our research in building an automated VR/AR synthesis system that would take as input the definition of a new routine in terms of existing routines in the library and well-defined mathematical/logical constraints and synthesize the program for the desired routine using constraint programming. We illustrate the ideas by means of an example.

Banerjee, B., & Chandrasekaran, B. (2007). A Framework for Planning Multiple Paths in Free Space. In In Proceedings of 25th Army Science Conference, Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Path planning, a topic of much interest in military planning, is largely treated as the task of finding the best path with respect to some criterion such as length, travel time, etc, for which efficient algorithms are already available. Military planning requires understanding enemy intentions and devising unexpected plans to fox the enemy which calls for not a best path, but a number of alternative paths. We study the problem of computing multiple paths with different properties, such as all paths with at most L loops, in free space among polygonal obstacles using a framework of Voronoi diagram. The complexity of the algorithms have been analyzed. We show that the Voronoi diagram, though widely used, is inadequate to represent certain important properties of representative paths in free space. Further, we show how this framework might be applied in three different military problems – entity reidentification, ambush analysis, and rapid re-routing in urban operations.

Banerjee, B., & Chandrasekaran, B. (2007). On Automating Perceptions and Actions in Reasoning with Military Diagrams. In In Proceedings of 25th Army Science Conference, Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Decision support systems should be able to handle representing and reasoning with diagrams, since they are a major component of representations in army situation understanding and planning. Diagrams are useful because desired information about spatial properties of and relations among diagrammatic objects can be perceived from a diagram directly. Spatially relevant changes in a situation or plan can be encoded by modifying a diagram appropriately. In this paper, we present an approach for automating perceptions and actions on a diagram to assist in visual reasoning needed for army decision making. The required perceptions and actions are defined in terms of properties and relations to be satisfied by a set of diagrammatic objects. This paper investigates the use of spatial constraint satisfaction for automatically synthesizing solutions for perceptions and actions. Our research goal is to develop a high-level language that is finite, extensible, humanusable, and expressive enough to describe the properties of desired perceptions and actions as constraints specified in terms of well-defined mathematical/logical functions and predefined perceptions/actions; to compute the solutions of the desired perceptions/actions and diagrammatically represent the outcome for actions; and to automatically synthesize their programs, thereby transforming them into readily executable routines. The ideas are illustrated by several examples.

Banerjee, B., & Chandrasekaran, B. (2007). Representations and Strategies for Solving Spatial Problems with Diagrams. In In Proceedings of 2007 IEEE Symposium on Visual Languages and Human-Centric Computing, Coeur d'AlŠne, Idaho.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Spatial problems (SP) are inevitable in reasoning with diagrams. In this paper, we investigate general representations and computational strategies for a SP-solver such that it can accept problems from a human in a high-level language and output the solution without human intervention. We propose a language in which a variety of domainindependent 2D SPs can be specified in terms of constraints. The constraints are specified in first-order logic over the real domain using a vocabulary of objects, properties, relations and actions. We also propose two general and independent computational strategies – constraint satisfaction and spatial search – for autonomously solving the SPs. Ideas about how to make these strategies computationally efficient are discussed and illustrated by examples.

Banerjee, B., & Chandrasekaran., B. (2007). Chapter 26. A Constraint Satisfaction Framework for Visual Problem Solving. In F. Benhamou, N. Jussien, & B. O'Sullivan (Eds.), Trends in Constraint Programming: Hermes Science.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
AI models problem solving as a search for a path to a goal state from an initial state. Traditionally, the underlying representations have been in the so-called symbolic framework, i.e. the goal, the states and the operators that transform the states are all represented, as compositions of predicate-symbolic structures, similar to natural language. However, in real-world problem solving, states and operators often have perceptual components, such as when diagrams are used in problem solving. In diagrammatic reasoning (DR), problem solving proceeds opportunistically. In addition to the traditional symbolic state transformations, perception may be called upon to extract certain information from the diagram, or actions may be taken on the diagram to create or modify parts of it to satisfy a given description. For example, a problem solving episode might need the information whether there is a school within five miles of the agent's home. The agent has to solve appropriate visual problems - abstract his home and all schools in a given map as points, calculate the distances of schools from his home, and compare them to five miles - to extract the required information.

We proposed and implemented a constraint satisfaction framework for solving visual problems relevant to DR. The specification language is set-theoretic with constraints specified in first order logic. We have expressed and solved a number of problems including those that require constraint solving as well as constraint optimization, with discrete as well as continuous domains. Though most of the problems were solved efficiently, there were two problems - grouping and computing the shortest path - that required searching through a combinatorially large set of solutions. We also illustrated how our problem solver grows smarter by solving more problems.

Barnes, M., Broome, B., & Chandrasekaran, B. (2003). Knowledge Environments to Support Horizontal Fusion. In In Proceedings of Army Science Conference. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
While a great deal of technology is in place to support the tenets of DoD's Horizontal Fusion program, considerable research must be accomplished to achieve the program's goals of a network customized to its users, providing both shared situation awareness and data availability that is limited only by policy. This paper outlines some of the issues that must be addressed to make that vision a reality and some of the current Army Research Laboratory initiatives in place to address them.

Barnes, M. J., McDermott, P., Hutchins, S., Gillan, D. J., & Rothrock, L. (2003). The Presentation of Risk and Uncertainty in the Context of National Missile Defense Simulations. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003 (pp. 197-200). College Park, MD: U.S. Army Research Laboratory.

Key Words:
Human Performance

Summary abstract:
Risk perception and uncertainty management are an important component of military decision making, especially in time-stressed and resource-limited environments. This series of experiments seeks to understand how to present information to take advantage of human heuristics while minimizing cognitive biases. We have taken into account research on uncertainty perception, framing, mental models, and perceptual format. The result is a first experiment that varies the format of information, the presentation mode, and the frame of information to determine the effect on decision making and situation awareness in a National Missile Defense (NMD) paradigm. Subjects had to decide how to allocate a reserve supply of defensive missiles in dynamic NMD scenarios in which U.S. cities were attacked. A pilot study was conducted to determine which graphical format best supported situation awareness and thus would be used in the simulation study. Results from the pilot study indicated that a "square" representation better supported situation awareness with only a minimal time increase. Results from the simulation study are pending and will be presented in the poster.

Bennett, K. B., Behymer, K., Stansifer, C., Shattuck, L., Talcott, C., & Martinez, S. (2003). Interface Design for Mobile Army Commanders. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society Conference. Denver, CO. (pp. 625-629).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The progress in developing and evaluating a prototype interface for mobile, forward-positioned Army commanders is reported. This interface currently includes novel representations of friendly and enemy combat resources and control mechanisms to re-focus granularity of attention. Army domain experts contributed substantially to design and evaluation activities: existing and proposed interfaces were reviewed, iterative design feedback was provided, a

simulated combat scenario was designed, and three empirical evaluations have been performed with Army officers as participants. The evaluations have compared the RAPTOR interface with a simulated version of the Army's current computerized interface (FBCB2); the RAPTOR interface has generally produced better performance. The next step is to incorporate graphical representations of plans into the interface. These representations will include information regarding time, space, objectives, and resources. The design goal is to facilitate comparisons between pre-planned objectives for the engagement and the actual progress that is being made. Ultimately these graphical representations should facilitate a commander's capability to determine when current progress toward goals and resource expenditures have deviated (either positively or negatively) from plan.

Bennett, K. B., Posey, S. M., & Shattuck, L. G. (2008). Ecological Interface Design for Military Command and Control. Journal of Cognitive Engineering and Decision Making, 2(4. Winter 2008), 349-385.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
The authors use the cognitive systems engineering framework to design and evaluate an interface for military command and control. They discuss analytic tools and principles of this framework and provide concrete examples (e.g., work domain analyses for U.S. Army tactical operations at the battalion level). They also discuss principles of ecological interface design, including direct perception, direct manipulation, and the perception-action loop. The translation between work domain analyses and the specific characteristics of the interface are made explicit. The authors describe the potential for this interface to support effective decision making and problem solving, including links with naturalistic decision-making approaches. Evaluations of the interface have been positive and are described briefly. Actual or potential applications of this research include both specific interface design strategies for military command and control and general interface design principles for this category of work domain.

Bennett, K. B., & Shattuck, L. (2005). Advanced Interfaces to Support Continuous Planning and Re-Planning During Tactical Operations. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
A research program to develop decision support for mobile Army commanders has resulted in a prototype interface. This interface was developed using principles of Cognitive Systems Engineering, and initial evaluations were very positive. This demonstration showcases recent design efforts to support re-planning during tactical operations, which are extremely demanding and critical for mission success. Unfortunately, these activities have received relatively little attention from the research community. The prototype interface has been designed to assist the commander in performing these activities. This interface highlights key elements of the battle plan (i.e., the intended course of events), the battle execution (i.e., the actual course of events as they unfold over time), and the differences between them.

Bennett, K. B., & Shattuck, L. G. (2009). Chapter 7. Advancing the State-of-the-Art in Military Command & Control Interfaces: Ecological Interface Design. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section II. Presenting Battlefield Information to Warfighters: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23,

2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
The discipline of human factors and ergonomics emerged as a direct result of problems encountered in military systems during World War II. Advances in technology (e.g., radar and sonar) created new capabilities and opportunities; it also created the potential for new kinds of failures (some subtle, some spectacular). Military contexts continue to be a proving ground for technological innovation. For example, a wide variety of new forms of data have become available for today's military decision makers (e.g., fuel and ammunition levels in individual vehicles, sensor data, sattelite and UAV imagery, etc.). Similarly, advances in graphical display and interface technology (e.g., high-resolution, bit-mapped screens) provide new options in the presentation of these data. Together, these new technological advances provide the potential to improve the efficiency and effectiveness of military operations.
Unfortunately, this potential is not being realized. Existing Army systems grossly under-utilize these display and interface resources. To be fair, it should be noted that it is not a problem that is germane to just the Army; the same criticisms can be leveled at many other work domains as well. The general question is how can we leverage the potential that is provided by today's hardware and software technology in the design of our socio-technical systems? More specifically, in the context of Army command and control: How do we go about designing interfaces that commanders will find both powerful and easy to use?
This chapter reviews a research program that was conducted under the ARL ADA CTA program with these questions in mind. An ecological interface was designed to support mobile battalion-level commanders during tactical operations. The particulars of this interface, the framework which guided its development, and the implications for display and interface design in general will be discussed.

Benvegnu, E., Suri, N., Hanna, J., Combs, V., R., W., & Kovach, J. (2009). Improving Timeliness and Reliability of Data Delivery in Tactical Wireless Environments with Mockets Communications Library. In In Proceedings of 2009 IEEE Military Communications Conference (MilCom 2009), Boston, MA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Network centric warfare relies on the timely and reliable delivery of data to disparate cooperating nodes in tactical networking environments. Given the limited bandwidth available and the unreliability of network links, data often accumulates in application and/or network queues, resulting in increased latency in the delivery of the data. The Mockets communications library addresses this problem via dynamic message replacement. The message replacement functionality of Mockets allows the system to drop all but the most recent message within a specific message flow by removing older, outdated messages from the queues. This paper describes and evaluates, in the context of the U.S. Air Force's Joint Battlespace Infosphere (JBI) system, the timeliness of end-to-end delivery of data using the Mockets library.
In addition to dynamic message replacement, other capabilities in the Mockets library include options for reliable vs. unreliable and sequenced vs. unsequenced delivery of data, detailed statistics and feedback regarding the connection, and assignment and dynamic adjustment of priorities of messages. This paper provides a qualitative analysis of these different capabilities and their suitability to address the transport requirements in JBI. It also provides a quantitative comparison of Mockets with SCTP and SCPS-TP, which are similar technologies with existing available candidate implementations. Our results show that the Mockets library with the message replacement significantly outperforms these other transport protocols.

Bharathan, V., & Josephson, J. R. (2006). An Abductive Framework for Level One Information Fusion,. In In Proceedings of Fusion 2006: The 9th International Conference on Information Fusion, Florence (Italy).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Artificial Intelligence, Tracking and Surveil-
lance, Fusion Architecture, C4ISR, Situation Assessment.

Summary abstract:
This article argues for, and describes some of the advantages of, construing Level One Information Fusion, as a task of Abductive Infer- ence or Inference to the Best Explanation. Such an approach enables certain benefits, such as, an expectation-based critique of hypotheses, and an ele- gant system for revising old beliefs, which may gain- fully be exploited. It also introduces several relevant dimensions to reasoning based on the exlanatory re- lations between hypotheses and data, that are closed to traditional approaches. The design principles of a software system, Smart-ASAS, that attempts to solve the Level One Fusion task of entity tracking and re-identification, are described, along with an example that illustrates its capabilities.

Bharathan, V., & Josephson, J. R. (2006). Belief Revision Controlled by Meta-Abduction. Logic Jnl IGPL, Oxford University Press, 14(2), 271-285.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
We describe an abductive reasoning agent that is able to change its mind and appropriately revise previous conclusions when it encounters a reasoning dilemma. Abductive inference (by which we mean "Inference to the Best Explanation") is an ampliative inferential process; that is, the conclusion goes beyond merely extracting information already present in the premises, perhaps unobviously. Thus, abductive inference is inherently fallible, and so it is desirable for a reasoning agent relying on abduction to be able to correct mistaken previous conclusions. A number of frameworks have been proposed for how to model and implement the logic of how an agent might change its mind: the non-monotonic reasoning techniques of default reasoning, Justification (and Assumption)-based truth maintenance systems and AGM theory, are prominent examples. These approaches, whatever their differences, share the property that they all seek universal solutions to the problem of belief revision, In contrast, we propose to take advantage of the specific structure of abductive reasoning to identify revision candidates among earlier beliefs, to propose specific revisions, to select among possible revisions, and to make the requisite changes to the system of beliefs. These adjustments are performed through meta-abductive processing over the recorded steps in an abductive agent's reasoning trace.

Bharathan, V., & Josephson, J. R. (2007). Detecting and Correcting Mistakes in Information Fusion. In In Proceedings of 25th Army Science Conference, Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This article scrutinizes one inherent pitfall in automated information fusion - its fallibility as an artifact of dealing with the real world. Since it is highly desirable to avoid contamination of further processing by past mistakes, we investigate the nature of the recovery process in a prototype agent that performs the Level One Information Fusion task of entity tracking and re-identification, Smart- ASAS. Smart-ASAS attempts to solve this fusion task by treating it as one of Abductive Inference or Inference to the Best Explanation. We discover that the problem space bounding recovery from errors is exponential in nature, but investigate the possibility of handling this computationally complex problem with some proposed heuristics that would result in some satisficing solution.

Binder, W., & Suri, N. (2009). Green Computing: Energy Consumption Optimized Service Hosting. In In Proceedings of 35th International Conference on Current Trends in Theory and Practice of Computer Science (SOFSEM-2009), Czech Republic. Lecture Notes in Computer Science (LNCS), Volume 5404, pp. 117-128.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Green computing, energy conservation, energy efficiency, data centers, service hosting, service dispatch, service-level agreements

Summary abstract:
Green Computing is a recent trend towards designing, building, and operating computer systems to be energy efficient. While programs such as Energy Star have been around since the early 1990s, recent concerns regarding global climate change and the energy crisis have led to renewed interest in Green Computing. Data centers are a significant consumers of energy - both to power the computers as well as to provide the necessary cooling. This paper proposes a new approach to reduce energy utilization in data centers. In particular, our approach relies on consolidating services dynamically onto a subset of the available servers and temporarily shutting down servers in order to conserve energy. We present initial work on a probabilistic service dispatch algorithm that aims at minimizing the number of running servers such that they suffice for meeting the quality of service required by service-level agreements. Given the estimated energy consumption and projected growth in data centers, the proposed effort has the potential to positively impact energy consumption.

Bolstad, C. (2005). Measuring Distributed Situation Awareness. In In Proceedings of Cognitive Performance 05 workshop, Las Vegas, NV.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Distributed Teams
• Predominant structure for command and control operations
• Need new methods analyze and assess team performance
• Difficulties For Distributed Teams
  § Rapidly Changing Environment
  § Large Amounts of Data
  § Sharing Information Between and Across Units
• Distributed Teams Need High SA

Definition of SA
Situation Awareness is the Perception of the Elements in the Environment within a Volume of Time and Space, the Comprehension of their Meaning, and the Projection of their Status in the Near Future. (Endsley, 1988)

Bolstad, C., Schneider, M., Graham, J., & Gonzalez, C. (2004). Collaborative Tools and Shared Mental Models. In In Proceedings of 48th Annual Meeting of the Human Factors and Ergonomics Society. New Orleans, LA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This paper reports on an experiment conducted to measure collaboration tool usage and shared mental models in Army Command and Control. Several teams of soldiers participated in a two-week simulation experiment. During the simulation, the run was stopped and participants completed a 5-minuted on-line questionnaire in which they were asked to rate their workload and other teammates workload as well as provide information on the collaboration tools used during the last hour of the exercise. Shared mental models was measured using congruency between each person’s rating of their own workload and their teammates perception of their workload. Overall, using the same

collaboration tool, irrespective of the tool type, to communicate between team members lead to higher shared mental models.

Bolstad, C. A., Cuevas, H. M., Costello, A. M., & Rousey, J. (2005). Improving Situation Awareness through Cross-Training. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This study investigated how cross-training, particularly in a leadership role, may assist individuals in better understanding the task requirements of their fellow team members, and, thereby, increase their shared situation awareness. Data was collected from a training exercise at the Joint Personnel Recovery Agency. Participants were assigned to one of 4 teams (Navy, Army, Special Ops, or Joint Service) and completed a simulated exercise designed to mimic real life events in a recovery center. Each player was rotated though the various positions and teams such that everyone had a chance to be a team director (lead person) and a team member in each of the 4 teams. Situation awareness was measured during the exercise using the SAGAT technique. Overall, results suggest that cross-training may lead to improved situation awareness. Participants, on average, exhibited greater situation awareness following experience in the director role than prior to director experience.

Bolstad, C. A., Cuevas, H. M., Gonzalez, C., & Schneider, M. (2005). Modeling Shared Situation Awareness. In In Proceedings of 14th Conference on Behavior Representation in Modeling and Simulation (BRIMS), Universal City, CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Situation Awareness, Social Network Analysis, Distributed Team Performance

Summary abstract:
This study presents an initial computational model of shared situation awareness (SA) based upon data collected from a simulated training exercise, designed to mimic real life events in a military personnel recovery center. Situation awareness was measured during the exercise using the Situation Awareness Global Assessment Technique (SAGAT). Our initial model examined how well five factors (social network distance, physical distance, rank similarity, branch similarity, and experience similarity) predicted shared SA. Overall, regression analyses highlighted the significant influence of geographical distribution (physical distance) on the development of shared SA and frequency of communications amongst team members. The discussion centers on the need for developing useful technological tools and techniques for supporting communication and collaboration among distributed teams.

Bolstad, C. A., & Endsley, M. R. (2003). Measuring Shared and Team Situation Awareness in the Army's Future Objective Force. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society Conference. Denver, CO. (pp. 369-373).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
A simulation exercise was conducted to assess the effectiveness of a new Army force structure called Objective Force. This paper will describe how shared and team situation awareness (SA) were measured and analyzed in this experiment with regards to how well the new force structure supports both SA at the individual officer level, within teams and across teams. Shared and Team SA were measured using the Situation Awareness Global Assessment Technique (SAGAT).

Bolstad, C. A., & Endsley, M. R. (2003). Tools for Supporting Distributed Team Collaboration. In In Proceedings Of The Human Factors And Ergonomics Society 47th Annual Meeting—2003 Human Factors and Ergonomics Association (HFEA).

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Collaboration plays an important role in team tasks. Teams are also functioning more often in a distributed fashion. If individuals are to work efficiently in a distributed fashion they will need collaborative tools and systems to exchange information and most importantly Situation Awareness (SA). Little guidance exists as to which tools are appropriate for coiiaborative tasks or situations. The present paper presents a taxonomy of collaboration and, based on this taxonomy, information is provided on which classes of collaborative tools and techniques are most useful for different types of tasks and situations.

Bolstad, C. A., & Endsley, M. R. (2003). Tools for Supporting Team Collaboration. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society Conference. Denver, CO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
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Bolstad, C. A., & Endsley, M. R. (2003). Tools for Supporting Team Situational Awareness (SA) and Collaboration in Army Operations. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making

Summary abstract:
Situation awareness (SA) plays an important role in Army operations. Within the future Objective Force, considerable effort is being directed at developing tools to improve SA for individual soldiers and for supporting shared SA and collaboration across teams. Little guidance exists as to which tools are appropriate for collaborative tasks or situations. The present paper presents a taxonomy of collaboration and, based on this taxonomy, information is provided on which classes of collaborative tools and techniques are most useful to the Army for different types of tasks and situations.

Bolstad, C. A., & Endsley, M. R. (2004). Collaboration Tools for the Army's Future Force. In In Proceedings of the Human Performance, Situation Awareness and Automation: Issues and Considerations for the 21st Century Conference, Daytona Beach, FL.

Key Words:

An Annotated Bibliography of Studies and Reports Produced by the Advanced Decision Architectures Consortium of the Collaborative Technology Alliance from 2001 to 2010

ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings Collaboration Tools, Team Performance, Situation Awareness, Army

Summary abstract:
Collaboration tools are used to facilitate the communication and exchange of information among team members who are working together to complete a shared task. The Army has under development a wide variety of tools for supporting collaboration. In addition, many commercial products have also been developed for supporting collaborative activities. Each of these tools offers very different types of capabilities, however, and little guidance exists as to which tools provide the highest levels of situation awareness (SA) and are appropriate for which types of collaborative tasks or situations relevant to Army Operations. An evaluation of these tools for Army command and control operations was conducted in a simulation exercise at Ft. Leavenworth. Overall, soldiers found to that faceto-face communication, a domain mapping tool and instant messaging were most effective for their tasks.

Bolstad, C. A., & Endsley, M. R. (2004). Collaboration Tools for the Army's Future Force. In In Proceedings of Human Performance, Situation Awareness and Automation: Issues and Considerations for the 21st Century. Daytona Beach, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings Collaboration Tools, Team Performance, Situation Awareness, Army

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Bolstad, C. A., & Endsley, M. R. (2005). Measurement of Situation Awareness in Military Operations. In In Proceedings of Cognitive Performance 05 workshop, Las Vegas, NV.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Goals of SA Measurement

- Investigations of SA in Military Operations
  - What are the critical skills/abilities that lead to high SA?
  - What factors hinder SA the most?
  - How do soldiers maintain SA under harsh operational conditions?
  - What strategies lead to high SA?
  - How does SA develop within and between teams?
- Evaluation of System Designs
  - Do new technologies actually improve SA?
  - Which aspects of SA are hurt by technology?
- Evaluation of Training Programs
  - How effective are new training techniques?

Bolstad, C. A., & Endsley, M. R. (2006). Choosing Team Collaboration Tools: Lessons from Disaster Recovery Efforts. Ergonomics in Design, 13(4), 7-14.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Extraodinary situations, such as natural disasters, teach us the importance of matching communication support tools to the task.
ON DECEMBER 26, 2004, THE MOST powerful earthquake in more than 40 years struck deep under the Indian Ocean, triggering massive tsunamis that obliterated cities, seaside communities, and holiday resorts. It killed more than 150,000 people in a dozen countries (CNN, 2004). A complex coordination and collaboration effort between relief organizations and government agencies was started to deliver aid to the survivors. At the time of this writing, 25 developed countries and 79 major international organizations had provided aid for this effort (CNN, 2005bj Nationmaster, 2005). However, collaboration among these organizations did not go smoothly.
This massive relief operation brought food and medicine to most large population groups but, nearly a month after the tragedy, continued to be hampered by insufficient coordination, according to a draft report by Rob Holden, worldwide operations manager for the World Health Organization (Nakashima, 2005). Although the sheer complexity of this operation overshadows most team collaboration efforts, it points out the need for useful collaboration tools and techniques to aid these and other organizations' interactions.
In this article, we present examples of coordination issues associated with a major natural disaster and how collaboration tools are being used to support the coordinated relief efforts.

Bolstad, C. A., Riley, J. M., Jones, D. G., & Endsley, M. R. (2002). Using Goal Directed Task Analysis with Army Brigade Officers. In In Proceedings of 46th Annual Meeting of the Human Factors and Ergonomics Society. Baltimore, MD.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
A greater understanding of team cognitive processes can be facilitated by identifying the individual goals of the team members and their situation awareness (SA) requirements. In some environments, such as military operations, the shear complexity, size, and composition of the team make this research quite challenging. Using a form of cognitive task analysis, we have developed an approach to address some of these team issues. In this paper we discuss the use of goal directed cognitive task analysis (GDTA) to obtain an accurate depiction of the SA requirements and key goals for several brigade officers. We further discuss how this information is being used to address team issues such as designing systems for enhancing team performance and decision making with Army brigade officers.

Bolstad, C. A., Wright, M., Endsley, M. R., & Jones, D. G. (2003). Measurement of Shared Situation Awareness in the Future Objective Force. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures

Summary abstract:
A simulation exercise was conducted at the end of January at the Battle Command Battle Lab at Fort Leavenworth with the Objective Force Unit of Action (UA) structure. This paper will describe how situation awareness (SA) was measured in this experiment and will describe how the data will be analyzed with regards to how well the new force

structure supports both SA at the individual officer level, within teams (e.g., within a UA cell), and across teams (e.g., between UA cells).

Bower, J. I. (2004). The Impact of Multimedia Communications on Understanding and Recall: An Empirical Study. In In Proceedings of 48th Annual Meeting of the Human Factors and Ergonomics Society. New Orleans, LA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This research focused on the design of software environments to support rich asynchronous communication and to understand the impact of such communications on understanding and recall in a military context. The goal was to explore how the design of a multimedia asynchronous communication tool influenced the understanding and recall of information. 46 ROTC cadets each received a company Operations Order, and based on that were required to write a platoon OPORD followed by two recall questions. Half of the cadets received the company OPORD in a conventional text format that included a static map overlay. The other half received the OPORD with 4 subsections presented with a multimedia presentation tool that included synchronized animation and voice narration. Overall, our findings show that the group that viewed the multimedia presentation recalled mission critical information 26-47% more often.

Boy, G., & Bradshaw, J. M. (2004). Interaction Design of Highly Automated Domain-Specific Systems. In In Proceedings of ACM SIGCHI Conference on Human Factors in Computing Systems (CHI 2004) World Computer Conference (WCC). Vienna, Austria.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The main learning objectives are to introduce practitioners and researchers to emerging changes in the way people interact with machines, and in particular to the shift from direct manipulation to agent management in specific domains such as aviation, space exploration, military, nuclear industry, automobile industry, telecommunications, and medicine. By the end of the tutorial, participants will be able to better understand and more effectively use current concepts in interaction design of highly automated domain-specific systems.
The major features of this tutorial are: an introduction to similarities and differences between human-centered and technology-centered approaches to interaction design of highly automated domain-specific systems; a development of the concept of cognitive function as a common entity that is useful for the representation of both human and software agents (i.e., automation); a presentation of the necessary cognitive science knowledge within the scope of the currently emerging industrial agent technology; a presentation of the tradeoffs between direct manipulation and agent management; live and video demonstrations of how agents can be used to facilitate the communication, cooperation and coordination between various activities that include training and operations.
The lecturers will invite participants to interact as much as possible providing to the overall group their questions and problems from their own domain and situation. Some exercises will be devoted to solving some of these questions in a very interactive way. In addition, the GEM pRoom software will be used to carry out effective participatory design of human-centered automation. Depending on the number of attendees, the sessions may be differently organized. The instructors will need to know the approximate number of attendees a while in advance to organize the final setup of the course.

Bradshaw, J., Uszok, A., Jeffers, R., Suri, N., Hayes, P., Burstein, M., Acquisti, A., Benyo, B., Breedy, M., Carvalho, M., Diller, D., Johnson, M., Kulkarni, S., Lott, J., Sierhuis, M., & Van Hoof, R. (2003). Representation and Reasoning for DAML-Based Policy and Domain Services in KAoS and Nomads. In In Proceedings of 2nd International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS 2003). Melbourne, Australia.

An Annotated Bibliography of Studies and Reports Produced by the Advanced Decision Architectures Consortium of the Collaborative Technology Alliance from 2001 to 2010

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
social order, conventions, norms, social control; cultural
norms and institutions, ontologies for agents and social
modeling; ontologies in agent-based information systems and
knowledge management, DAML, policy, domains, KAoS,
Nomads, human-agent teamwork, adjustable autonomy,
coalition, augmented cognition, cognitive prosthesis

Summary abstract:
To increase the assurance with which agents can be deployed in operational settings, we have been developing the KAoS policy and domain services. In conjunction with Nomads strong mobility and safe execution features, KAoS services and tools allow for the specification, management, conflict resolution, and enforcement of DAML-based policies within the specific contexts established by complex organizational structures. In this paper, we will discuss results, issues, and lessons learned in the development of these representations, tools, and services and their use in military and space applications

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Bradshaw, J. M., Jung, H., Kulkarni, S., & Taysom, W. (2004). Dimensions of Adjustable Autonomy and Mixed-Initiative Interaction. In M. Nickles, M. Rovatsos, & G. Weiss (Eds.), Agents and Computational Autonomy: Potential, Risks, and Solutions. Lecture Notes in Computer Science. Also Presented At: Presentation at the University of Rochester. Rochester, Ny (Vol. 2969, pp. 17-39). Berlin: Springer Verlag.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Several research groups have grappled with the problem of characterizing and developing practical approaches for implementing adjustable autonomy and mixed-initiative interaction in deployed systems. However, each group takes a little different approach and uses variations of the same terminology in a somewhat different fashion. In this chapter, we will describe some common dimensions in order to better understand these important but ill-characterized topics. We will also sketch the approach to implementation we are developing in the context of our research on policygoverned autonomous systems.

Bradshaw, J. M., Feltovich, P. J., Jung, H., Kulkarni, S., Allen, J., Bunch, L., Chambers, N., Galescu, L., Jeffers, R., Johnson, M., Sierhuis, M., Taysom, W., Uszok, A., & Van Hoof, R. (2005). Policy-Based Coordination in Joint Human-Agent Activity. In In Proceedings of IEEE International Conference on Systems, Man, and Cybernetics. The Hague, The Netherlands.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Policy, KAoS coordination, joint activity, human-agent interaction

Summary abstract:
In this paper, we outline an approach to policy based coordination in joint human-agent activity. The approach is grounded in a theory of joint activity originally developed in the context of discourse, and now applied to the broader realm of human agent interaction. We have been gradually implementing selected aspects of policy based coordination within the KAoS services framework and have been developing a body of examples that will guide additional testing of these ideas through detailed studies of work practice.

Bradshaw, J. M. (2008). How to Do with Owl What People Say You Can't. In In Proceedings of 2008 IEEE Conference on Policy, Palisades, NY.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
WHAT IS OWL?
¢ OWL stands for Web Ontology Language
¢ OWL is built on top of RDF and written in XML
¢ OWL was designed to be interpreted by computers, not people
¢ OWL has three sublanguages: OWL-Full, OWLDL, and OWL-Lite
¢ OWL is a Web standard
¢ The use of OWL is not restricted to Web applications

Bradshaw, J. M., Acquisti, A., Allen, J., Breedy, M., Bunch, L., Chambers, N., Galescu, L., Goodrich, M., Jeffers, R., Johnson, M., Jung, H., Kulkarni, S., Lott, J., Olsen, D., Sierhuis, M., Suri, N., Taysom, W., Tonti, G., Uszok, A., & van-Hoof, R. (2004). Teamwork-Centered Autonomy for Extended Human-Agent Interaction in Space Applications. In In Proceedings of AAAI Spring Symposium. Stanford, CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This paper summarizes our efforts to bring together and extend the best in current theory and technologies for teamwork-centered autonomy for space applications. Traditional planning technologies at the foundation of intelligent robotic systems typically take an autonomycentered approach, with representations, mechanisms, and algorithms that have been designed to ingest a set of goals and output a complete plan in the most efficient and sound fashion possible. A teamwork-centered autonomy approach, on the other hand, takes as a beginning premise that people are working in parallel alongside autonomous systems, and hence adopts the stance that the processes of understanding, problem solving, and task execution are necessarily incremental, subject to negotiation, and forever tentative. Thus, a successful approach to teamwork-centered autonomy will require that every element of the autonomous system be designed to facilitate the kind of give-and-take that quintessentially characterizes natural and effective teamwork among groups of people. We briefly describe the major components of this approach and current efforts to apply and evaluate its utility from both human-centered and cost-benefit perspectives.

Bradshaw, J. M., Beautement, P., Breedy, M. R., Bunch, L., Drakunov, S. V., Feltovich, P. J., Hoffman, R. R., Jeffers, R., Johnson, M., Kulkarnt, S., Lott, J., Raj, A. K., Suri, N., & Uszok, A. (2004). Chapter 12. Making Agents Acceptable to People. In N. Zhong and J. Liu (Eds.), Intelligent Technologies for Information Analysis: Advances in Agents, Data Mining, and Statistical Learning. Pp. 355-400.
Also Presented at the Following Conferences:
- Third International Central and Eastern European Conference on Multi-Agent Systems (Ceemas 2003). Prague, Czech Republic, 2003.
- Invited Presentation to Science Applications International Corporation (Saic), Orlando, Fl., 2005.
- Invited Colloquium. University of Georgi, Athens, 2005.
- Third Annual Cognitive Systems Workshop, Santa Fe, Nm, 2005.
- Invited Lecture, King Fahd University of Petroleum and Minerals, Dammam, Saudi Arabia, 2006. Berlin: Springer Verlag.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Because ever more powerful intelligent agents will interact with people in increasingly sophisticated and important ways, greater attention must be given to the technical and social aspects of how to make agents acceptable to people. The technical challenge is to devise a computational structure that guarantees that from the technical standpoint all is under control. The social challenge is to ensure that agents and people interact gracefully and to provide reassurance to people that all is working according to plan. In this chapter, we outline our efforts to address some of these technical and social concerns through the use of a policy-based approach as implemented in the KAoS framework. From a technical perspective, we want to be able to help ensure the protection of agent state, the viability of agent communities, and the reliability of the resources on which they depend. To accomplish this, we must guarantee, insofar as is possible, that the autonomy of agents can always be bounded by explicit enforceable policy that can be continually adjusted to maximize the agents' effectiveness and safety in both human and computational environments. From a social perspective, we want agents to be designed to fit well with how people actually work together. Explicit policies governing human-agent interaction, based on careful observation of work practice and an understanding of current social science research, can help assure that effective and natural coordination, appropriate levels and modalities of feedback, and adequate predictability and responsiveness to human control are maintained. These factors are key to providing the reassurance and trust that are the prerequisites to the widespread acceptance of agent technology for nontrivial applications.

Bradshaw, J. M., Cabri, G., & Montanari, R. (2003). Taking Back Cyberspace. IEEE Computer, 89-92.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Certain roles in society carry with them such a high level of fiduciary responsibility that the appropriate organizations carefully monitor and control them through licensing, credentials, and periodic formal review. To the degree that our personal welfare depends on such people, we count trustworthiness the most important prerequisite of our willingness to commit aspects of our lives and resources into their hands. For similar reasons, people expect a high level of trustworthiness before delegating complex and important tasks to software agents.

Bradshaw, J. M., Feltovich, P. J., Johnson, M., Bunch, L., Breedy, M., Jung, H., Lott, J., & Uszok, A. (2008). Coordination in Human-Agent-Robot Teamwork. In In Proceedings of 2008 International Symposium on Collaborative Technologies and Systems (CTS 2008), Special Session on Collaborative Robots and Human Robot Interaction, Irvine, CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Coordination is an essential ingredient of a teamworkcentered approach to autonomy. In this paper, we discuss some of the challenges and requirements for successful coordination, and briefly how we have used KAoS HART services to support coordination in a multi-team human robot field exercise.

Bradshaw, J. M., Jung, H., Kulkarni, S., Allen, J., Bunch, L., Chambers, N., Feltovich, P., Galescu, L., Jeffers, R., Johnson, M., Taysom, W., & Uszok, A. (2004). Toward Trustworthy Adjustable Autonomy and Mixed-Initiative Interaction in KAoS. In In Proceedings of AAMAS 2004 Trust workshop (pp. 9-20). New York City, NY.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Trust is arguably the most crucial aspect of agent acceptability. Many aspects of trust can be addressed through policy. Policies are a means to dynamically regulate the behavior of system components without changing code or requiring the cooperation of the components being governed. By changing policies, a system can be continuously adjusted to accommodate variations in externally imposed constraints and environmental conditions. In this paper we describe some important dimensions relating to autonomy and give examples of how these dimensions might be adjusted in order to enhance performance of human-agent teams. We then offer a definition of mixed-initiative interaction and give examples of relevant policies. We introduce Kaa, the KAoS adjustable autonomy component. Finally, we provide a brief comparison with two other implementations of adjustable autonomy concepts.

Bradshaw, J. M., Jung, H., Kulkarni, S., Johnson, M., Feltovich, P., Allen, J., Bunch, L., Chambers, N., Galescu, L., Jeffers, R., Suri, N., Taysom, W., & Uszok, A. (2005). Kaa: Policy-Based Explorations of a Richer Model for Adjustable Autonomy. In In Proceedings of Fourth International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS 05) Utrecht University, The Netherlands.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Categories and Subject Descriptors
I.2.11 [Artificial Intelligence]: Distributed Artificial Intelligence
– intelligent agents, multiagent systems.
General Terms
Performance, Reliability, Human Factors
Keywords
Adjustable Autonomy, Policy, Trust, Human-agent Teamwork,
KAoS, Kaa, OWL

Summary abstract:
Though adjustable autonomy is hardly a new topic in agent systems, there has been a general lack of consensus on terminology and basic concepts. In this paper, we describe the multi-dimensional nature of adjustable autonomy and give examples of how various dimensions might be adjusted in order to enhance performance of human-agent teams. We then introduce Kaa (KAoS adjustable autonomy), which extends our previous work on KAoS policy and domain services to provide a policy-based capability for adjustable autonomy based on this richer notion of adjustable autonomy. The current implementation of Kaa uses a combination of ontologies represented in OWL and influence-diagram-based decision-theoretic algorithms to determine what if any changes should be made in agent autonomy in a given context. We have demonstrated Kaa as part of ONR sponsored research to improve naval de-mining operations through more effective human-robot interaction. A brief comparison among alternate approaches to adjustable autonomy is provided.

Bradshaw, J. M., Jung, H., Kulkarni, S., Johnson, M., Feltovich, P., Allen, J., Bunch, L., Chambers, N., Galescu, L., Jeffers, R., Suri, N., Taysom, W., & Uszok, A. (2005). Toward Trustworthy Adjustable Autonomy in Kaos. In R. Falcone (Ed.), Trusting Agents for Trustworthy Electronic Societies. Berlin: Springer-Verlag Berlin Heidelberg.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Trust is arguably the most crucial aspect of agent acceptability. At its simplest level, it can be characterized in terms of judgments that people make concerning three factors: an agent's competence, its benevolence, and the degree to which it can be rapidly and reliably brought into compliance when things go wrong. Adjustable autonomy consists of the ability to dynamically impose and modify constraints that affect the range of actions that the humanagent

team can successfully perform, consistently allowing the highest degrees of useful autonomy while maintaining an acceptable level of trust. Many aspects of adjustable autonomy can be addressed through policy. Policies are a means to dynamically regulate the behavior of system components without changing code or requiring the cooperation of the components being governed. By changing policies, a system can be adjusted to accommodate variations in externally imposed constraints and environmental conditions. In this paper we describe some important dimensions relating to autonomy and give examples of how these dimensions might be adjusted in order to enhance performance of human-agent teams. We introduce Kaa (KAoS adjustable autonomy) and provide a brief comparison with two other implementations of adjustable autonomy concepts.

Bradshaw, J. M., Sierhuis, M., Acquisti, A., Feltovich, P., Hoffman, R., Jeffers, R., Suri, N., Uszok, A., & Hoof, R. V. (2003). Living with Agents and Liking It: Addressing the Technical and Social Acceptability of Agent Technology. In In Proceedings of Spring 2003 AAAI Symposium on Human-Agent Interaction in Complex Environments. Menlo Park, CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This paper summarizes our efforts to address some of the technical and social aspects of agent design for increased human acceptability. From a technical perspective, we want to be able to ensure the protection of agent state, the viability of agent communities, and the reliability of the resources on which they depend. To accomplish this, we must guarantee insofar as possible that the autonomy of agents can always be bounded by explicit enforceable policy that can be continually adjusted to maximize their effectiveness and safety in both human and computational environments. From a social perspective, we want agents to be designed so as to fit well with how people actually work together. Explicit policies governing human-agent interaction based on careful observation of work practice and an understanding of current social science research can help assure that effective and natural coordination, appropriate levels and modalities of feedback, and adequate predictability and responsiveness to human control are maintained. We see these technical and social factors as key to providing the reassurance and trust that are prerequisite to the widespread acceptance of agent technology for nontrivial applications.

Bradshaw, J. M., Suri, N., Breedy, M., Cañas, A., Davis, R., Ford, K., Hoffman, R., Jeffers, R., Kulkarni, S., Lott, J., Reichherzer, T., & Uszok, A. (2002). Terraforming Cyberspace. In In Proceedings of Workshop on Process Coordination and Ubiquitous Computing. Orlando: University of Central Florida.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
During the 1940s, under the pseudonym of Will Stewart, Jack Williamson published a series of fictional stories describing a process for attaching atmospheres to planets in order to make them capable of sustaining life. 'Terraforming,' the term he coined for this activity was first picked up by other science fiction writers. Eventually, it captured the imagination of a small but zealous core of scientists, space advocacy groups, and segments of the public who began focusing on Mars as the most likely target for transformation and eventual colonization. The May 1991 issue of Life Magazine ran a cover story describing a 150-year plan for a Martian metamorphosis through orbiting solar reflectors that would melt polar water, surface factories that would produce needed gases in the atmosphere, and the ultimate planting of hearty plant species as the temperature approached the freezing point of water. Today many articles, books, and Web sites continue to develop the theme.

Branlat, M., Fern, L., Voshell, M., & Trent, S. (2009). Understanding Coordination Challenges in Urban Firefighting: A Study of Critical Incident Reports In In Proceedings of 53rd Annual Meeting of the Human Factors and Ergonomics Society, San Antonio, TX.

Key Words:

ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This paper explores the central role played by coordination during fire incident response. Following preliminary investigations based on other methods, the authors analyzed a corpus of 29 critical incident reports produced by one fire department's safety services. Urban firefighting is a complex domain in which members' activities need to be highly synchronized in order to reach common operational and safety goals. As the work environment challenges the capacity of firefighters to coordinate efficiently, coordination breakdowns might occur, creating safety threats as role interdependencies become difficult to manage.

Brewer, I., McNeese, M. D., Frazier, T. G., Fuhrmann, S., & Terrell, I. S. (2005). Expanding Team Knowledge Elicitation through Procedural, Temporal, and Strategic Elements. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Current research within knowledge elicitation and cognitive task analysis (see Schraagen et al. 2000 for multiple examples) is typically applied to individual activities rather than teamwork. Yet, when analysts conduct cognitive fieldwork, the possibility exists to also work with groups of experts. In some cases, these groups may be intact (as a "workgroup") and operate as a cohesive unit in processing information and requests. In other cases, experts may work individually but be brought together to share their collective knowledge on given issues and aspects of the cognitive task analysis. Because teamwork is absolutely important in many facets of complex problems (especially in encountering emergency situations that require joint coordination, communication, and control of resources), it is useful to engage in team knowledge elicitation for either case mentioned.

Bunch, L., Bradshaw, J. M. & Young, C. O. (2008). Policy-Governed Information Exchange in a Us Army Operational Scenario. In In Proceedings of 2008 IEEE Conference on Policy, Palisades, NY.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The authors are investigating how emerging policy and semantic web technologies can be used to help provide the best set of available tactical information to the Soldier in the field. In this initial effort, Researchers from the U.S. Army Research Labs (ARL) and the Florida Institute for Human and Machine Cognition (IHMC) have developed a system that demonstrates the potential of these technologies in a small-scale U.S. Army mockup scenario. The system represents and reasons about domain-specific policies to help recognize what documents the end Soldier is allowed to receive given the current mission context. The system also relies on policies to help recognize when appropriate human approval can be obtained or a specific transformation of the information can be performed to allow the information to be sent. Semantic web technologies are further used to describe the properties and features of each document and relate these features to mission contexts in which the information is likely to be appropriate. The result is a compelling demonstration of the role that policies and semantic web technologies can play in promoting the Army's need to share information while remaining vigilant of the requirements to protect methods and sources.

Bunch, L., Bradshaw, J. M., Johnson, M., Lott, J., J.Feltovich, P., Suri, N., Carvalho, M., Tokarcik, L., Winkler, R., & Metu, S. (2009). Chapter 4. Regulating the Exchange of Tactical Military Information Using the Kaos Policy Services Framework. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section I. Collecting, Processing and Distributing Battlefield Information: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the

Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
Sharing tactical information among joint forces, coalition partners, and non-government organizations (NGOs) can be critical to successful and safe operations. Unfortunately, the need to share information is sometimes at odds with the sensitivity of battlefield information. Frequently, the flow of data across heterogeneous channels and among diverse groups must be tightly regulated. This presents significant operational challenges, including successful negotiation of the multi-level, interdependent, and sometimes conflicting agency and interagency aims, governed formally by policy and chains of command, and informally by cultural and organizational norms.
IHMCand ARL are collaborating to develop software systems in which information is passed seamlessly across mUltiple organizations, networks, and individuals while respecting complex and possibly conflicting sets of policies. In support ofthis objective, we have created capabilities that allow us to automatically and dynamically identify, in a contextsensitive way, when requisite operational and situational imperatives warrant the automated (or semi-automated) declassification and dissemination of sensitive but perishable combat data. Moreover, we are exploring mechanisms for abstracting and transforming information to enable it to fulfill requirements for sharing, for example, by redacting the content or metadata of messages or by delaying their delivery until a critical situation is over. By providing automated mechanisms to help identify relevant sensitive but perishable data in the Collateral Space that can be released, transformed, or delayed with appropriate levels of human oversight and approval, lives can be saved and time wasted in performing these tedious tasks manually can be significantly reduced or eliminated. Our approach includes the use of an extensible standards-based policy representation to specify formal policy statements about the tactical domain. The KAoS Policy and Domain Services framework provides a graphical interface for quickly constructing policies in readable English in a point-and-click fashion at run-time. KAoS also provides innovative formal ontology-based policy analysis and deconfliction mechanisms and highly-efficient mechanisms for policy monitoring and enforcement. It also includes many powerful features that enhance its usefulness in real battlefield situations (e.g., support for standalone or disconnected operations, spatial and temporal reasoning). We integrate this policy reasoning capability with distributed middleware components capable of enforcing such policies in a MANET (mobile adhoc network) environment

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Bunch, L., Breedy, M., Bradshaw, J. M., Carvalho, M., Danks, D., & Suri, N. (2005). Flexible Automated Monitoring and Notification for Complex Processes. In In Proceedings of IEEE International Conference on Networking, Sensing, and Control, Tucson, AZ.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
UoS, KARMEN, OWL, Monitoring, Multi-Agent System, Notification

Summary abstract:
Automated monitoring for complex systems such as the space shuttle fueling and launch process can increase the effectiveness of operators in detecting abnormal conditions before become hazardous to the point they may compromise the mission. We have developed the KAoS Reactive Monitoring and Event Notification (KARMEN) multi-agent system to allow users to describe and change monitoring conditions at any time in order to effectively monitor such processes and appropriately notify key operations personnel about off-nominal conditions. These notification actions are overseen by policies that contain process requirements and users preferences.

Bunch, L., Breedy, M., Bradshaw, J. M., Carvalho, M., & Suri, N. (2005). Karmen: Multi-Agent Monitoring and Notification for Complex Processes. In In Proceedings of HoloMAS Conference 2005, Copenhagen, Denmark.

Key Words:

An Annotated Bibliography of Studies and Reports Produced by the Advanced Decision Architectures Consortium of the Collaborative Technology Alliance from 2001 to 2010

ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Early and consistent detection of abnormal conditions is important to the safe and efficient operation of complex industrial processes. Our research focuses on enabling the operators and engineers who control and maintain such systems tO,describe process conditions to software agents, deploy such agents to continuously monitor live process data, and receive appropriate notification from their personal agents concerning the process state. The resulting dynamic population of monitoring agents is managed by our agile computing framework according to policies that define computing and networking resource restrictions as well as user notification requirements and preferences.

Burke, C. S., Fiore, S. M., & Salas, E. (2003). Chapter 5. The Role of Shared Cognition in Enabling Shared Leadership and Team Adaptability In C.L. Pearce and J.A. Conger (Eds.), Shared Leadership: Reframing the How's and Why's of Leadership. Pp. 103-122. Thousand Oaks, CA: Sage Publishers.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Organizations are increasingly using teams as a predominant strategy when faced with environments characterized by complexity and ambiguity. These teams are typically composed of two or more members who work interdependently and adaptively to accomplish a common goal or mission. Such teams typically have specific role assignments and they often disband once the goal is reached or mission is completed (Salas, Dickinson, Converse, & Tannenbaum, 1992). Moreover, due to the complicated nature of the tasks facing those in industry and the military, these teams are increasingly becoming cross-functional (see Northcraft, Polzer, Neale, & Kramer, 1995; Knight et al., 1999). Despite the proposed benefits of work teams (see Swezey & Salas, 1992), many real world examples have illustrated that they are not always effective (Hackman, 1990). Key among the reasons for the failure of teams to live up to their potential are (a) the failure to smoothly coordinate member action and (b) a lack of effective leadership to guide the coordination process. In fact, some have argued that the team leader's failure to guide and structure team experiences that facilitate the development and maintenance of coordinative, adaptive action can be a key factor in ineffective performance (Stewart & Manz, 1995). Clearly, coordinative, adaptive action is vital to successful team performance.

Burke, C. S., Fowlkes, J. E., Wilson, K. A., & Salas, E. (2003). A Concept of Soldier Adaptability: Implications for Design and Training. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures

Summary abstract:
Adaptability has been argued to be a defining characteristic of effective teams (Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995). Additionally, as military missions are increasingly varied, complex, and dynamic requiring soldiers to complete their missions in the presence of asymmetric threats adaptability is ever more important. Despite the need for adaptive action and adaptive teams, recent evidence from the operational literature has suggested several barriers to adaptive team performance in the military. Many of these barriers can be eliminated or mitigated through training or system design. However, there has yet to be much attention given or guidance offered for training soldier adaptability or designing systems to facilitate soldier adaptability. Thereby, the purpose of the present paper is to illustrate a theoretical concept of adaptability, the key tenets that form this concept, and a translation of these tenets into training and design implications. We also offer a set of conceptually derived training and design guidelines, a subset of which are being empirically validated.

Burke, C. S., Fowlkes, J. E., Wilson, K. A., & Salas, E. (2003). A Concept of Soldier Adaptability: Implications for Design and Training. In In Proceedings of Annual Conference for the Collaborative Technology Alliance Program, pp. 143-148. Baltimore, MD.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Adaptability has been argued to be a defining characteristic of effective teams (Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995). Additionally, as military missions are increasingly varied, complex, and dynamic requiring soldiers to complete their missions in the presence of asymmetric threats adaptability is ever more important. Despite the need for adaptive action and adaptive teams, recent evidence from the operational literature has suggested several barriers to adaptive team performance in the military. Many of these barriers can be eliminated or mitigated through training or system design. However, there has yet to be much attention given or guidance offered for training soldier adaptability or designing systems to facilitate soldier adaptability. Thereby, the purpose of the present paper is to illustrate a theoretical concept of adaptability, the key tenets that form this concept, and a translation of these tenets into training and design implications. We also offer a set of conceptually derived training and design guidelines, a subset of which are being empirically validated.

Burke, C. S., Stagl, K. C., Salas, E., Pierce, L., & Kendall, D. (2007). Understanding Team Adaptation: A Conceptual Analysis and Model. Journal of Applied Psychology, 91(6), 1189-1207.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
teams, teamwork, team adaptation, adaptability, team effectiveness

Summary abstract:
This endeavor provides a multidisciplinary, multilevel, and multiphasic conceptualization of team adaptation with theoretical roots in the cognitive, human factors, and industrial– organizational psychology literature. Team adaptation and the emergent nature of adaptive team performance are defined from a multilevel, theoretical standpoint. An input–throughput– output model is advanced to illustrate a series of phases unfolding over time that constitute the core processes and emergent states underlying adaptive team performance and contributing to team adaptation. The cross-level mixed-determinants model highlights team adaptation in a nomological network of lawful relations. Testable propositions, practical implications, and directions for further research in this area are also advanced.

Carley, K. M. (2007). Dynamic Network Analysis for Counter-Terrorism. In In Proceedings of Kilby Lecture at the GOMATech 07, Lake Buena Vista, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Dynamic network analysis (DNA) is an emergent field centered on the collection, analysis, understanding and prediction of dynamic relations (such as who talks to whom and who knows what) and the impact of such dynamics on individual and group behavior. DNA facilitates reasoning about real groups as complex dynamic systems that evolve over time. In this chapter, the basic tenets of DNA are described and contrasted with those of Social Network Analysis and Link Analysis. Some of the basic techniques are then illustrated through the analysis of data on al

Qaeda. Technology described enables the analyst to identify vulnerabilities in the terrorist network and to assess how that network might change in response to strategic interventions.

Carley, K. M. (2007). A Dynamic Network Approach to the Assessment of Terrorist Groups and the Impact of Alternative Courses of Action. In In Proceedings of RTO, NATO. DTIC ADM002067.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Dynamic network analysis (DNA) is an emergent field centered on the collection, analysis, understanding and prediction of dynamic relations among various entities such as actors, events and resources and the impact of such dynamics on individual and group behaviour. DNA facilitates reasoning about terrorist groups as complex dynamic networked systems that evolve over time. An interoperable DNA toolchain for collecting data on, assessing the network of, and forecasting changes in that network is presented. The use of these DNA tools to asses a terrorist group is then demonstrated using open source data. Key techniques are demonstrated using a dataset collected on terror networks. Techniques demonstrated include those for identification of an actor's sphere of influence, emergent leaders, and paths among critical actors, and metrics for assessing the potential immediate and near term impact of various courses of action.

Carley, K. M. (2009). Dynamic Network Analysis. In In Proceedings of NRC workshop on Social Network Modeling and Analysis, Ron Breiger and Kathleen M. Carley (Eds.), National Research Council.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Dynamic network analysis (DNA) varies from traditional social network analysis in that it can handle large dynamic multi-mode, multi-link networks with varying levels of uncertainty. DNA, like quantum mechanics, would be a theory in which relations are probabilistic, the measurement of a node changes its properties, movement in one part of the system propagates through the system, and so on. However, unlike quantum mechanics, the nodes in the DNA, the atoms, can learn. An approach to DNA is described that builds DNA theory through the combined use of multi-agent modeling, machine learning, and meta-matrix approach to network representation. A set of candidate metric for describing the DNA are defined. Then, a model built using this approach is presented. Results concerning the evolution and destabilization of networks are described.

Carley, K. M., Martin, M. K., & Hancock, J. P. (2009). Chapter 1. Dynamic Network Analysis Applied to Experiments from the Decision Architectures Research Environment. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section I. Collecting, Processing and Distributing Battlefield Information: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
ADA CTA research is producing experimental results from simulations of intermeshed networks of warfighters and battlefield surveillance' assets. These networks form a complex system with behaviors that emerge from patterns of interaction among constituent entities. The simulated interactions are spatially situated, temporally distributed

communications among people, robots, and software agents. In general terms, the complex system - parts of which we address in this paper - can be conceptualized as a two-level meta-network that includes interactions among human agents at one level, interactions among artificial agents at another level, and cross-level interactions between human and artificial agents.
The issue addressed in this paper is Dynamic Network Analysis (DNA) of system behavior. For the purposes of this chapter, we are not interested in examining the performance of one system relative to another. Although this type of comparative analysis can be useful for researchers or system designers, it is of questionable use to warfighters. Instead, we are interested in analyses that produce tactically relevant, actionable results that highlight the strengths and weaknesses in the system being observed. To be useful, the analytical results must foster tactical insight and stimulate battlefield decisions that prudently influence future system behavior.
To this end, we describe two case studies that apply DNA to the simulated battlefield data being generated by experiments in the Decision Architectures Research Environment (DARE). The first case involves intercepts of simulated communications among human agents, which we frame as an exercise in adversarial reasoning. The second case involves simulated communications among surveillance assets (i.e., software agents and robots), which we frame as an exercise in understanding the automated control of a Persistent Coordinated Video Surveillance (PCVS) system. Together, we believe the case studies demonstrate how DNA (Carley, 2002) can foster tactical insight in complex multi-entity scenarios. They also demonstrate that the combination of DNA techniques required for tactical insight may vary according to the type of network being analyzed. Finally, they show how DNA assists in the development, understanding and tuning of software agent systems.

Carroll, M., Josephson, J. R. & Russell, J. L. (2007). Tradeoffs on the Efficient Frontier for the Disruption of Networks. In In Proceedings of IEEE Symposium on Computational Intelligence in Multi-Criteria Decision-Making (MCDM 2007), (http://www.ieeecis-multidecision.org/) Honolulu, Hawaii.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
A communications network is represented as a graph of flow capacities. We study the problem of finding good network disruption attacks or target sets, i.e., a subset of vertices or edges that, once removed, impede communication between particular nodes. Multiple costs are associated with removing vertices or edges. Success in disrupting communications is traded off against the costs of the attack plans: the efficient frontier of attacks is estimated, and the results are studied in crosslinked diagrams. A multicriterial genetic algorithm is used to discover good plans for disrupting the communications network, where the genes correspond to nodes or links to be attacked. The genetic algorithm is seeded with an initial population of single-target genomes, one for each potential target. Multi-target attacks may be generated by breeding. Being on the efficient frontier guarantees a genome's survival to the next generation, so the population size is allowed to vary. The results are studied in interactive diagrams and in an "aggregate view" of the resulting population. Good attacks were found relatively rapidly, and the aggregate view revealed significant targets.

Carvalho, M., Suri, N., Shurbanov, V. and Lloyd, E. (2007). A Cross-Layer Network Substrate for the Battlefield. In In Proceedings of 25th Army Science Conference, Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This paper describes the initial design and implementation of a cross-layer communications substrate for tactical networks. Traditional crosslayer strategies for MANETs often rely on the direct interaction between neighbor layers in the communications stack. We propose a different approach, where all lower layers (PHY, MAC and NET) directly interact with the overlying applications (or communications middleware). In this work, we discuss some of the requirements for cross-layer support in a tactical environment. We also introduce our proposed design for a cross-layer communications substrate for such environments, concluding the paper with a brief description of our current proof-of-concept implementation and future research proposal.

Carvalho, M., Granados, A., Brothers, A., Hanna, J. P., & Turck, K. (2009). A Cross-Layer Communications Substrate for Tactical Information Management Systems. In In Proceedings of MILCOM, San Diego.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In this paper we introduce XLayer, a cross-layer communications substrate for tactical Information Management Systems which enable nodes on a radio network to seamlessly communicate with nodes on different heterogeneous networks. While conventional cross-layer strategies for tactical environments tend to focus on the localized optimization between neighbor layers ofthe communications stack, our approach focuses on the interface between middleware and the underlying communications infrastructure.
The XLayer communications substrate leverages native information and services available at the tactical communications infrastructure to improve the functionally and capabilities of overlay applications and middleware. The XLayer also provides the necessary interfaces and mechanisms to enable application-driven requirements to parameterize and regulate the operation ofthe underlying communications infrastructure.
After a brief description of the target environment and system requirements we will introduce the proposed design for the cross-layer communications substrate, highlighting specialized controllers and adaptors for communication interfaces and tactical radios. We will then introduce new cross-layer strategies for discovery, routing and transport targeted to Information Management System (IMS)-support, followed by our NS-2 simulation results, analysis, and conclusions.

Carvalho, M., Granados, A., Perez, C., Arguedas, M., Winkler, R., Kovach, J., & Choy, S. (2009). Chapter 5. Xlayer: A Cross-Layer Communications Substrate for Tactical Environments. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section I. Collecting, Processing and Distributing Battlefield Information: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
Tactical and mobile ad hoc networks (MANETs) are key technology enablers for future mission-critical communication infrastructures such as those envisioned for disaster relief operations and military missions.
The self-organizing nature of MANETs enables the on-demand formation of temporary communications capabilities to support the operation of mission-critical applications in the edges of main communications infrastructure, a critical capability for military operations.
However, this unprecedented capability comes at a price. The stability and reliability generally observed in fixed communications infrastructures, which are often leveraged and assumed by tactical applications and decision architectures, are no necessarily available in MANETs (at least at similar levels). The flexibility that enables the on-demand formation of MANETs also creates a new type of communications environment, one that is dynamic and significantly more resource constrained.
While there has been a significant amount of research focused primarily on building new MANET technologies and protocols that would provide better predictability and reliability, it is widely accepted today that a practical solution will likely require a better interaction between application and communications infrastructure. The traditional layered approach that has shielded applications from the underlying networks is no longer applicable, and new challenge has emerged-how to provide such interface (or mutual awareness) while avoiding customized stovepiped solutions.

The notion of a cross-layer communications substrate for tactical battlefield environments described in this work proposes to address the problem by enabling a two-way interface between higher-level applications, middleware or decision architectures, and the underlying communications infrastructure.
In this work we summarize our research for the development of XLayer, a cross-layer communications substrate designed to provide and support communication infrastructures for the battlefield.
The goal is to provide a modular architecture and a set of interfaces that 1) allows applications and decision architecture systems to better adapt to and leverage the characteristics of the dynamic communications environment and, 2) enables the underlying communications infrastructure to better support application requirements and constraints.
In support of the application and decision architecture systems, XLayer monitors, abstracts, and represents the characteristics and capabilities of the underlying communications infrastructure so applications can better adapt to changes in the underlying communications environment (by re-allocating resources, for example).
In support of the communications infrastructure, applications can provide information about resource requirements (both computational and communications) or utilization patterns. This information can then be used by the underlying communications infrastructure to better allocate resources and capabilities in response to changes that may occur either on demand or proactively, based on explicit application requirement patterns.

Carvalho, M., Perez, C., & Granados, A. (2009). Dynamic Gateway Selection for Cross-Domain Routing with the Xlayer Communications Substrate. In In Proceedings of International Workshop on Scalable Ad Hoc and Sensor Networks (SASN 2009), Saint Petersburg, Russia.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This paper describes a dynamic gateway selection algorithm for cross-domain routing. The proposed cross-layer algorithm is designed on top of the XLayer communications substrate. In the context of this work, cross-domain routing refers to seamlessly routing across different networks running different routing algorithms without pre-defined gateways or a common underlaying protocol. We first provide a brief introduction of the XLayer communications substrate and the adaptive routing controller. After describing the algorithm and a summary of the proposed architecture, a proof-of-concept implementation is evaluated for a simple scenario developed in NS-2. Our preliminary results are encouraging and show the potential of our proposed strategy for dynamic gateway selection and crossdomain routing.

Carvalho, M., Suri, N., & Arguedas, M. (2006). Mobile Agent-Based Communications Middleware for Data Streaming in the Battlefield. In In Proceedings of MILCOM 2005 Conference, Atlantic City, NJ.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In this paper we introduce the FlexFeedframework in the context of military combat operations. FlexFeed realizes the notion ofAgile Computing for data-streaming and implements a flexible, robust and efficient publishlsubscribe infrastructure for dynamic ad hoc environments under resource and policy constraints. The framework uses mobile software agents for underlying configuration and policy enforcement. The paper illustrates the effectiveness of the framework with quantitative experiments over simulated scenarios.

Carvalho, M., Suri, N., Arguedas, M., Rebeschini, M., & Breedy, M. (2007). A Cross-Layer Communications Framework for Tactical Environments. In In Proceedings of MILCOM 2006, Washington, D.C. Also Invited Talk at BAE Systems and Invited talk at the Federal University of Brasilia, Brazil.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In this paper we propose a cross-layer approach for information and resource sharing between the routing, transport and application-level components in tactical networks. Our approach is different than traditional crosslayer strategies for MANETs in that itfocuses on the interaction of each layer (MAC and NET) directly with the overlying applications (or middleware), as opposed to the traditional interactions between neighbor layers in the OSI model. In this work, 'applications' are abstracted by a data-aware communication framework that resides on top ofthe transport layer and interacts will all sub-layers. The paper describes the requirements for cross-layer integration, and introduces our proposed approach. A proof-ofconcept implementation is presentedfor the Agile Computing Middleware and the OLSR routing protocol.

Cekova, C., Chandrasekaran, B., Josephson, J., & Pantaleev, A. (2006). Simulation-Based Planning for Peacekeeping Operations: Selection of Robust Plans. In The International Society for Optical Engineering (SPIE) Defense and Security Symposium, Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings modeling, simulation, robustness, selection of robust plans, course of action, COA, Course of Action analysis Approach

Summary abstract:
This research is part of a proposed shift in emphasis in decision support from optimality to robustness. Computer simulation is emerging as a useful tool in planning courses of action (COAs). Simulations require domain models, but there is an inevitable gap between models and reality - some aspects of reality are not represented at all, and what is represented may contain errors. As models are aggregated from multiple sources, the decision maker is further insulated from even an awareness of model weaknesses. To realize the full power of computer simulations to support decision making, decision support systems should support the planner in exploring the robustness oieGAs in the face of potential weaknesses in simulation models.
This paper demonstrates a method of exploring the robustness of a COA with respect to specific model assumptions about whose accuracy the decision maker might have concerns. The domain is that of peacekeeping in a country where three different demographic groups co-exist in tension. An external peacekeeping force strives to achieve stability, an improved economy, and a higher degree of democracy in the country. A proposed COA for such a force is simulated multiple times while varying the assumptions. A visual data analysis tool is used to explore COA robustness. The aim is to help the decision maker choose a COA that is likely to be successful even in the face of potential errors in the assumptions in the models.

Cevher, V., Guo, F., Sankaranarayanan, A. C., & Chellappa, R. (2007). Joint Acoustic-Video Fingerprinting of Vehicles, Part II. In In Proceedings of ICASSP 2007.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings Object recognition, pattern recognition, acoustic applications, acoustic signal processing, intelligent sensors

Summary abstract:
In this second paper, we first show how to estimate the wheelbase length of a vehicle using line metrology in video. We then address the vehicle fingerprinting problem using vehicle silhouettes and color invariants. We combine the acoustic metrology and classification results discussed in Part I with the video results to improve estimation performance and robustness. The acoustic video fusion is achieved in a Bayesian framework by assuming conditional independence of the observations of each modality. For the metrology density functions, Laplacian approximations are used for computational efficiency. Experimental results are given using field data.

Chadwick, R., Pazuchanics, S. L., & Gillan, D. (2008). Visual-Cognition Challenges for the Operation of Unmanned Ground Vehicles SPIE Newsroom,-http://spie.org/x26118.xml.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
The psychology of remote-operator environmental awareness is an important area of inquiry in which recent advances enable improved deployment of robotic vehicles.
The use of unmanned ground vehicles (UGVs) allows for remote sensing and action in hazardous environments at a safe distance. Proponents of UGV deployment for both military and civilian applications must overcome technical challenges faced in realizing their full potential. The development of operationally effective UGVs remains demanding due to the complexity of autonomous ground navigation and the cognitive requirements on human operators. These difficulties appear across a variety of UGV applications, including the use of large autonomous vehicles for reconnaissance or convoy operations and the deployment of small remotely operated vehicles for explosives disposal or urban search-and-rescue tasks.1

Chadwick, R. A. (2005). The Impacts of Multiple Robots and Display Views in an Urban Search and Rescue Simulation. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The use of remote controlled uninhabited ground vehicles (UGVs) is expanding in military and emergency operations. In operations involving multiple UGVs controlled by a single operator, understanding the psychological implications for operational proficiency with the integration of multiple displayed viewpoints is critical. The current empirical study addresses this issue in an experimental simulation of an urban search and rescue (USAR) operation. Using miniature vehicles in a simulated environment, participants were tasked with searching through difficult terrain to photograph specific targets. In the experiment, the number of UGVs used and the use of an uninhabited air vehicle (UAV) view were manipulated as between participants variables. Results indicate: (1) that the use of two UGVs (in a team mode) is rather inefficient, (2) that using two UGVs did not meaningfully reduce faults, and (3) that the use of a UAV view, and to a lesser extent two UGVs, improved target localization.

Chadwick, R. A. (2006). Operating Multiple Semi-Autonomous Robots: Monitoring, Responding, Detecting. In In Proceedings of 50th Annual Meeting of the Human Factors and Ergonomics Society. San Francisco CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The concept of one operator controlling multiple unmanned ground vehicle (UGV) robots is examined in a simulation of a multiple UGV search task. Semi-autonomous robotic UGVs were simulated searching for radioactive targets while operators performed various sub-tasks including monitoring status, responding to prompted target decision events, and detecting contextual errors. Participants executed a series of scenarios using 1, 2, or 4 UGVs simultaneously. The detection of contextual errors is particularly difficult when multiple vehicles are being supported. Specific interface features designed to assist with multiple vehicle operations are discussed including a quick video playback (QVP) function.

Chadwick, R. A. (2008). Considerations for the Use of Aerial Views in Unmanned Ground Vehicle Operations. In In Proceedings of 52nd Annual Meeting of the Human Factors and Ergonomics Society. 22-26 September 2008. New York City, NY USA. New York City, NY USA: HFES.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Remote unmanned ground vehicle (UGV) operations place the human operator at a perceptual disadvantage. Adding aerial views can benefit the operator's spatial cognition by supplying the missing contextual information regarding the vehicle's position and relation to other objects in the space surrounding the vehicle. In order to benefit from this additional information the operator must control and integrate multiple viewpoints. In a series of experiments the use of aerial views was examined including control mode options and altitude for the aerial scene imaging. Results indicate that aerial views are beneficial in UGV search tasks and that auto-tracking aerial imaging control modes should be considered.

Chadwick, R. A., & Gillan, D. J. (2007). Strategies for the Interpretive Integration of Ground and Air Views in UGV Operations. In In Proceedings of 25th Army Science Conference, Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Two experiments examined the cognitive process of aerial view target localization. Participants were shown ground-view images with designated targets, and tasked with locating the target in an aerial view. The first study examined photographic image sets in both a qualitative and quantitative manner, including a think-aloud protocol analysis. The second study used manipulated three dimensional model images to isolate effects of color, shape, and other attributes. Results show a strong cue dominance effect for unique colors, sex differences, and minor view angle effects. We discuss a proposed cognitive model for this task and suggest recommendations for assistive unmanned ground vehicle (UGV) interface features.

Chadwick, R. A., & Gillan, D. J. (2008). Cognitive Integration of Aerial and Ground Views in Remote Vehicle Operations. In In Proceedings of SPIE Symposium on SPIE Defense and Security Symposium, Unmanned Systems Technology, Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Unmanned ground vehicles, UGV, unmanned air vehicles, UAV, view integration

Summary abstract:
Both unmanned air vehicles (UAVs) and unmanned ground vehicles (UGVs) are being used in increasingly complex roles as this technology matures. There are many proposals for the joint use of UAVs and UGVs working together to achieve mission goals. Due to the spatial perception difficulties commonly reported in UGV operations, it has been postulated that the operation of UGVs could benefit from the use of live aerial views in scenarios where this is possible. In a series of experimental studies we examine the cognitive task of integrating air and ground views. Integrating these views is a key cognitive task component in UGV operations which usually require that maps for navigation be integrated with imagery from ground view cameras. Whether aerial views are used or not, integration with map views is crucial. In this paper we discuss a series of experimental studies relevant to the cognitive integration of air and ground views in UGV scenarios. The integration of map and ground camera views may be facilitated by the use of live aerial views. In urban search scenarios the addition of an aerial view to a UGV operator's task does not appear to have any measurable negative consequences and improves localization performance.

Chadwick, R. A., Gillan, D. J., Simon, D., & Pazuchanics, S. (2004). Cognitive Analysis Methods for Control of Multiple Robots: Robotics on $5 a Day. In In Proceedings of 48th Annual Meeting of the Human Factors and Ergonomics Society. New Orleans, LA. (pp. 688-692).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Studies of a single operator controlling multiple robots were designed (1) to identify problems caused by perceptual and cognitive factors and (2) to propose interface concepts to reduce the problems. The studies used innovative techniques at extremely low cost. Existing artifacts, i.e., commercially-available video games played over local area networks, provided a rich source of data on control of one or multiple semiautonomous entities with a minimum of development. Psychological theories regarding various attributes of robotic operation, including perception, navigation, motion control, and information display are embedded in such artifacts. Custom scenarios involving multiple robots controlled by a single operator were developed to facilitate switching between tasks and, in some cases, cooperative use of the multiple robots. Findings include data on navigation difficulty, task switching strategies, mode errors, and perceptual confusion regarding multiple viewpoints.

Chadwick, R. A., & Pazuchanics, S. (2007). Spatial Disorientation in Remote Ground Vehicle Operations: Target Localization Errors. In In Proceedings of 51st Annual Meeting of the Human Factors and Ergonomics Society. Baltimore, MD.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Operating remote unmanned ground vehicles (UGVs) poses the risk of operator spatial disorientation. While the position of the vehicle can be tracked and displayed on a global map, operators face the difficult task of integrating object (target) information from context limited ground views with a global map view. Studies indicate this can be a challenging task. An analysis of specific object location errors is presented.

Chadwick, R. A., Pazuchanics, S. L., & Gillan, D. J. (2005). Chapter 26. What the Robot's Camera Tells the Operator's Brain. In N. Cooke and H. Pedersen (Eds.), Human Factors of Remotely Piloted Vehicles: Advances in Human Performance and Cognitive Engineering Research (pp. 373-384). Amsterdam: Elsevier.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
bThe failure of all 15 robotic entries at the 2004 DARPA Grand Challenge race across the Mojave Desert suggests that, for now, the possibility of fully autonomous robots is remote. Among the most natural and easy-to-do activities for mobile, adult humans is moving through space. However, that ease and naturalness belies the complexity of the perceptual, cognitive, and motor processes that underlie visually guided motion. Although the ease of human navigation may deceive robotics developers into believing that automating spatial navigation should be similarly straightforward, reliable solutions for autonomous navigation and localization in dynamic real world environments have not been found (Murphy et aI., 1993; Santos, Castro, & Ribeiro, 2000; Tomatis, Nourbakhsh, & Siegwart, 2003). Furthermore, autonomous navigation is the only one component of effective, reasoned autonomous operation. Given that teleoperations are likely to continue to be an important mode of robotic control for the foreseeable future, what perceptual information does the operator of a ground-based remotely operated vehicle (ROV) or of multiple ROVs need in order to navigate the system through space, and how should the information be presented to the operator?
This chapter will discuss observational studies and experiments performed in the Robotics Control Laboratory in the Psychology Department at New Mexico State University investigating the perceptual and cognitive processes involved when an operator controls two ROVs simultaneously. The research includes studies of operators

controlling virtual ROVs (e.g., using CeeBot, a software-based programmable robot simulation created by Epistec) or controlling minirobots in a miniature environment that, when seen through a video-based user interface, appears to be full sized.
The research that we summarize in this chapter includes (1) experiments on navigation using an egocentric or first person viewpoint, including the role of landmarks and toe use of maps, (2) studies of the size of the ROV's field of view and camera viewpoint, and (3) research on how operators integrate interface components that display spatial position information with camera-based views of the robots' positions to develop an awareness of the location of multiple ROVs. The chapter will also discuss the implications of integrating visual information provided to the operator via mUltiple ROVs, including both ground and air vehicles.

Chandrasekaran, B. (2002). Intelligent Systems as Control Systems: A Knowledge Level Perspective. In J.H.S. Azuela, C.A. Ibanez, M.A. Mentado, & A. Gelbukh (Eds.), Avances En Ciencias De La Computación E Ingeniería De Cómputo. Centro De Investigación En Computación-Ipn. Keynote Presentation, XI International Conference on Computing, Mexico City, November 25 to 29, 2002 (pp. 75-102): ISBN 970-18-8590-2.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section
Intelligent control, knowledge level analysis, intelligence as
control.

Summary abstract:
Intelligence, and intelligent systems, can be viewed from many perspectives: Turing computation, reasoning systems, search engines, dynamical systems, selectionist structures, and so on. In this paper, I elaborate a view of them as control systems – a view intended to be complementary, not opposed, to the other perspectives. A point of intelligent behavior is to achieve goals in complex environments, where the goals themselves are generally defined in terms of states of the environment. Thus behaving intelligently is a matter of organizing actions on the environment such that it is in desirable states and not in undesirable states. This is quintessentially the problem of control. What is it that unifies the control task in all its manifestations, from the thermostat to the operator of a nuclear power plant? How do we explain the variety of the solutions that we see for the task? I propose a Knowledge Level analysis of the task. Differences in availability of knowledge, the degree of compilation in the knowledge to map from observations to actions, and properties required of the solutions together determine the differences in the solution architectures. I propose a number of heuristics that arise out of the Knowledge Level analysis for the design of systems to control the physical world.

Chandrasekaran, B. (2002). Multimodal Representations as the Basis for Cognitive Architecture. In In Proceedings of ACT-R 2002 Workshop. Carnegie Mellon University. Pittsburgh, PA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
• Experiencing, problem solving, reasoning, takes place in the context of an external world that we perceive, act on, imagine and reason about in multiple modalities
  – Conceptual modality is always present
  – Different tasks emphasize different perceptual modalities
    • Music composition vs mechanical design
• In our framework, the internal representational life of the agent is multimodal, with representations in one mode evoking allied representations in other modes, and each mode making inferential contributions for which it is best suited. Mental images come in all modalities.

• Treats conceptual component as just another component with equal status with inner perceptual and kinesthetic components. In one way of thinking, having concepts is imaging the world in the conceptual world, just as having images is imaging the world in the perceptual mode.
• Logical rules of inference are just a very small part of the information extraction operators in the conceptual part.

Chandrasekaran, B. (2002). Reach Exceeds Grasp: Comments on Frawley's 'Control and Cross-Domain Mental Computation: Evidence from Language Breakdown'. Computational Intelligence, 18(1), 43-46.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
A particular version of the modular theory of cognition goes like this. Cognition consists of modules, each with its own domain of expertise. In this picture, a module does not interact directly with another module. A module reports the results of its activity to a central working memory (WM), with its own more or less complex structure. Tasks often require involvement of more than one module, thus setting up the problem of how the different modules work together. This problem is solved by having the modules not only report their results to the WM, but also by having the modules that need information from another module simply read off the WM the results reported by the latter module. This way, the task gets accomplished without the need for the modules to directly communicate with other modules. The WM plays the role of a central blackboard in this view.

Chandrasekaran, B. (2002). What Does It Mean for a Computer to Do Diagrammatic Reasoning?: A Functional Characterization of Diagrammatic Reasoning and Its Implications. In In Proceedings of Diagrams 2002 International Conference. Callaway Gardens, GA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
What is Diagrammatic Reasoning?
Consider some examples:
1. Proving syllogisms using Euler Diagrams: 1 + 3+ 5 +…(2n-1) = n2
For these problems, consider the diagram drawn on paper vs imagining vs a computer program doing it.

(i) Concrete version vs the infinite version
(ii) Subtle interplay of what perception gives and how it is combined with conceptual information

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Chandrasekaran, B. (2003). Design Problem Solving: Strands of My Research. In U. Lindemann (Ed.), Human Behavior in Design: Individuals, Teams, Tools (pp. 219-229). Heidelberg: Springer Verlag.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
My main research interest is cognitive architecture for intelligent agents. I have always driven my research by focusing on specific tasks that bring out the nature of thinking, and design problem solving has been one such task area. I have sought to identify what is common to all design activity, whether it is design of mechanical artifacts,

electronics systems, or software. What unifies all of my work on design is my interest in logical, ontological and computational bases of the generic design task. My work on design can be thought of in terms of strands of research that relate to one another.

Chandrasekaran, B., Kurup, U., Banerjee, B., Josephson, J., & Winkler, R. (2005). An Architecture for Problem Solving with Diagrams. In A. Blackwell, K. Marriott, & A. Shimojima (Eds.), Diagrammatic Reasoning and Inference, Lecture Notes in Artificial Intelligence. Pp. 151-165.=. 2980, Berlin: Springer Verlag.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
In problem solving a goal/subgoal is either solved by generating needed information from current information, or further decomposed into additional subgoals. In traditional problem solving, goals, knowledge, and problem states are all modeled as expressions composed of symbolic predicates, and information generation is modeled as rule application based on matching of symbols. In problem solving with diagrams on the other hand, an additional means of generating information is available, viz., by visual perception on diagrams. A subgoal is solved opportunistically by whichever way of generating information is successful. Diagrams are especially effective because certain types of information that is entailed by given information is explicitly available – as emergent objects and emergent relations – for pickup by visual perception. We add to the traditional problem solving architecture a component for representing the diagram as a configuration of diagrammatic objects of three basic types, point, curve and region; a set of perceptual routines that recognize emergent objects and evaluate a set of generic spatial relations between objects; and a set of action routines that create or modify the diagram. We discuss how domainspecific capabilities can be added on top of the generic capabilities of the diagram system. The working of the architecture is illustrated by means of an application scenario.

Chandrasekaran, B. (2005). Representing Function: Relating Functional Representation and Functional Modeling Research Streams. Artificial Intelligence for Engineering Design, Analysis and Manufacturing, Special Issue on Engineering Applications of Representations of Function, 19, 65-74.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Device Ontology; Device Structurc', Functional Modeling; Functional Representation: How Things Work

Summary abstract:
This paper is an informal description of some recent insights about what a device function is, how it arises in response to needs. and how function arises from the structure of a device and the functions of its components. These results formalize and darify a set of contending intuitions about function that researchers have had. The paper relates the approachs, results and goals of this stream of research called functional representation (FR), with the functional modeling (FM) stream in engineering.

Chandrasekaran, B. (2006). Diagrams as Physical Models to Assist in Reasoning. In L. Magnani (Ed.), Model Based Reasoning in Science and Engineering, Cognitive Science and Logic. Texts in Logic Series (pp. 1-16). London: King's College Publications. ISBN 1-904987-23-0.

Key Words:
ADA CTA

Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
abstract. Diagrams serve a variety of roles in applied reasoning. At times, they are best viewed as \sentences" in a 2-D language, with specialized rules of inference that provide new diagrams. Other times, however, they are best understood as providing a physical model, much like an architectural model of a building or a 3-D molecular model of a chemical compound, for a state of a®airs. In this paper, I discuss the notion of a physical model for a logical sentence, and the role played by the causal structure of the physical medium in making the given sentence as well as a set of implied sentences true. When the physical model is prototypical, it supports the inference of certain other sentences for which it provides a model as well. I also informally discuss a proposal that diagrams and similar physical models help to explicate a certain sense of relevance in inference, an intuition that so-called Relevance Logics attempt to capture.

Chandrasekaran, B. (2006). Diagrams as Physical Models. In D. Barker-Plummer, R. Cox, & N. Swoboda (Eds.), In Proceedings of Diagrams 2006, the International Conference on Diagrammatic Representations and Reasoning at Stanford University (pp. 204-217): Springer.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
focusing in particular on their role as physical models of states of affairs, much like an architectural model of a building or a 3-D molecular model of a chemical compound. We discuss the concept of a physical model for a logical sentence, and the role played by the causal structure of the physical medium in making the given sentence as well as a set of implied sentences true. This role of a diagram is consistent with a widely-held intuition that diagrams exploit the fact that 2-D space is an analog of the domain of discourse. One line of research in diagrammatic reasoning is that diagrams, rather then being models, are formal representations with specialized rules of inference that generate new diagrams. We reconcile these contrasting views by relating the usefulness of diagrammatic systems as formal representations to the fact that their rewrite rules take advantage of the diagrams' model-like character. When the physical model is prototypical, it supports the inference of certain other sentences for which it provides a model as well. We also informally discuss a proposal that diagrams and similar physical models help to explicate a certain sense of relevance in inference, an intuition that so-called Relevance Logics attempt to capture.

Chandrasekaran, B. (2006). Multimodal Cognitive Architecture: Making Perception & Body More Central to Intelligent Behavior. In In Proceedings of the AAAI National Conference on Artificial Intelligence. (www.aaai.org) (pp. 1508-1512.).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
I propose that the notion of cognitive state be broadened from the current predicate-symbolic, Language-of-Thought framework to a multi-modal one, where perception and kinesthetic modalities participate in thinking. In contrast to the roles assigned to perception and motor activities as modules external to central cognition in the currently dominant theories in AI and Cognitive Science, in the proposed approach, central cognition incorporates parts of the perceptual machinery. I motivate and describe the proposal schematically, and describe the implementation of a bi-modal version in which a diagrammatic representation component is added to the cognitive state. The proposal explains our rich multimodal internal experience, and can be a key step in the realization of embodied agents. The proposed multimodal cognitive state can significantly enhance the agent's problem solving.

Chandrasekaran, B. (2006). Multi-Modal Cognitive States: Augmenting the State in Cognitive Architectures. In In Proceedings of American Association for Artificial Intelligence Spring Symposium Series, Stanford, CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Different streams of AI idealize different aspects of human cognition. Idealization of intelligence as an embodied activity, involving an integration of cognition, perception and the body, places the tightest constraints on the design space for AI artifacts, forcing AI to deeply understand the design tradeoffs and tricks that biology has developed. I propose that a step in the design of such artifacts is to broaden the notion of cognitive state from the current linguistic-symbolic, Language-of-Thought framework to a multi-modal one, where perception and kinesthetic modalities participate in thinking. This is in contrast to the roles assigned to perception and motor activities as modules external to central cognition in the currently dominant theories in AI and Cognitive Science. I develop the outlines of this proposal, and describe the implementation of a bimodal version in which a diagrammatic representation component is added to the cognitive state.

Chandrasekaran, B. (2008). Designing Decision Support Systems to Help Avoid Biases & Make Robust Decisions, with Examples from Army Planning. In In Proceedings of 2008 Army Science Conference.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This paper is concerned with two sets of issues related to optimality in planning. The first is a proposal that design of decision support systems (DSS's) for planning should aim to support the planner in generating a plan that is robust, i.e., has satisfactory performance even when reality differs from assumptions. Such a plan would sacrifice optimality when reality is as assumed for reasonable performance over a larger range of situations. We discuss how this proposed refocus follows from the in-principle incompleteness, and common errorfulness, of domain models required to assess the performance of plans. The second issue related to optimality is the degree to which human judgment in planning is subject to a number of biases, all detracting from optimality. The Framing Bias arises from the Bounded Rationality of human cognition. The Transitivity Bias is a result of treating small and large differences in the criteria values as of equal importance. Our analysis leads to design recommendations for DSS's that provide a measure of protection against these biases. The ideas are motivated and illustrated with Army planning examples.

Chandrasekaran, B. (2009). Problem Solving Methods and Knowledge Systems: A Personal Journey to Perceptual Images as Knowledge. Artificial Engineering in Engineering Design and Manufacturing, Special Issue on Problem Solving Methods: Past, Present and Future, 2009, Vol. 23, No. 3.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Generic Tasks; Knowledge Systems; Problem Solving Methods

Summary abstract:
I was among those who proposed problem solving methods (PSMs) in the late 1970s and early 1980s as a knowledge-level description of strategies useful in building knowledge-based systems. This paper summarizes the evolution of my ideas in the last two decades. I start with a review of the original ideas. From an artificial intelligence (AI) point of view, it is not PSMs as such, which are essentially high-level design strategies for computation, that are interesting, but PSMs associated with tasks that have a relation to AI and cognition. They are also interesting with respect to cognitive architecture proposals such as Soar and ACT-R: PSMs are observed regularities in the use of knowledge that an exclusive focus on the architecture level might miss, the latter providing

no vocabulary to talk about these regularities. PSMs in the original conception are closely connected to a specific view of knowledge: symbolic expressions represented in a repository and retrieved as needed. I join critics of this view, and maintain with them that most often knowledge is not retrieved from a base as much as constructed as needed. This criticism, however, raises the question of what is in memory that is not knowledge as traditionally conceived in AI, but can support the construction of knowledge in predicate–symbolic form. My recent proposal about cognition and multimodality offers a possible answer. In this view, much of memory consists of perceptual and kinesthetic images, which can be recalled during deliberation and from which internal perception can generate linguistic– symbolic knowledge. For example, from a mental image of a configuration of objects, numerous sentences can be constructed describing spatial relations between the objects. My work on diagrammatic reasoning is an implemented example of how this might work. These internal perceptions on imagistic representations are a new kind of PSM.

Chandrasekaran, B., Banerjee, B., Kurup, U., Josephson, J. R., & Winkler, R. (2009). Chapter 21. Diagrammatic Reasoning in Army Situation Understanding and Planning: Architecture for Decision Support and Cognitive Modeling. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section IV. Communicating Information across the Team: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
Diagrams are ubiquitous in army decision-making. Commanders represent, communicate, and monitor their situation understanding and plans by means of diagrams drawn over terrain or other maps. Diagrams are so central in military applications that field manuals have standardized the elements of such representations. They are not only useful in spatial reasoning tasks, but also in tasks that are not directly related to space, as evidenced by bar and pie charts and Venn diagrams. The reason for their usefulness is that they enable an optimal combination of visual perception and symbolic reasoning: visual perception picks up information that is perceptually available in the diagram, avoiding chains of inference, while symbolic reasoning enables inferences that can only be made with abstract and distal knowledge.
We have two different sets of motivations for research in diagrammatic representations, and both are especially relevant to army decision support. The first is the need to understand what makes for good diagrams for a task, i.e., what graphical properties of a diagram make it easier for a human user to obtain the needed information fast and without error. This knowledge can be used to design effective diagrams and diagrammatic interfaces for interactive systems. Exploring the interaction between task demands, graphical properties, human cognitive and perceptual architecture, and the user's background knowledge that go into using a diagram is best done by building cognitive models. Designing and building a cognitive architecture that rises to the challenge of modeling diagrammatic reasoning has been a major concern of ourresearch.
The second motivation arises from the opportunity to enhance decision- making by automating some ofthe reasoning tasks. For example, consider replanning a route in real time in an urban engagement in response to rapid changes in the situation, especially if the changes are. occurring outside of the immediate surroundings of a soldier. For a soldier in the heat of the action, this task will be very demanding at best and impossible at worst. An automated diagrammatic reasoning system that can perform the needed rerouting fast and display the results in a form that the soldier can comprehend can be very helpful. As another example, a planner might desire to critique a planned avenue of approach with respect to risk of potential ambush. The complexity of the terrain may make the task time-consuming, but an automated diagrammatic reasoning system that can perform this task, as a demonstration system we have built does, can add real value. Both the research goalsautomation and cognitive modeling- have a common element: a general cognitive architecture that can perform diagrammatic reasoning by appropriately combining spatial information and abstract knowledge.

Chandrasekaran, B., & Goldman, M. (2007). Exploring Robustness of Plans for Simulation-Based Course of Action Planning: A Framework and an Example. In In Proceedings of IEEE Symposium on Computational Intelligence in Multi-Criteria Decision-Making (MCDM 2007), (http://www.ieeecis-multidecision.org/) Honolulu, Hawaii.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Planning requires evaluating candidate plans multicriterially, which in turn requires some kind of a causal model of the operational environment, whether the model is to be used as part of evaluation by humans or simulation by computers. However, there is always a gap - consisting of missing or erroneous information - between any model and the reality. One of the important sources of gaps in models is built-in assumptions about the world, e.g., enemy capabilities or intent in military planning. Some of the gaps can be handled by standard approaches to uncertainty, such as optimizing expected values of the criteria of interest based on assumed probability distributions. However, there are many problems, such as military planning, where it is not appropriate to choose the best plan based on such expected values, or where meaningful probability distributions are not available. Such uncertainties, often called "deep uncertainties," require an approach to planning where the task is not choosing the optimal plan as much as a robust plan, one that would do well enough even in the presence of such uncertainties. Decision support systems should help the planner explore the robustness of candidate plans. In this paper, we illustrate this functionality, robustness exploration, in the domain of network disruption planning, an example of effect-based operations.

Chandrasekaran, B., Josephson, J. R., Banerjee, B., Kurup, U., & Winkler, R. (2003). Diagrammatic Reasoning in Support of Situation Understanding and Planning. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures

Summary abstract:
Visual representations consisting of terrain maps with an overlay of diagrammatic elements are ubiquitous in Army situation understanding, planning and plan monitoring. The Objective Force requirements of responsiveness, agility and versatility call for digitized graphical decision support interfaces that automate or otherwise help in various reasoning tasks. The main purpose of the paper is to describe the issues involved in building a diagrammatic reasoning system, specifications for diagrammatic representation formalism, and an architecture for problem solving with diagrams. We report on the current state of implementation of an application that infers maneuvers from data about locations and motions of Blue and Red forces.

Chandrasekaran, B., Josephson, J. R., Banerjee, B., Kurup, U., & Winkler, R. (2003). Diagrammatic Reasoning in Support of Situation Understanding and Planning. In In Proceedings of Army Science Conference. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Visual representations consisting of terrain maps with an overlay of diagrammatic elements are ubiquitous in Army situation understanding, planning and plan monitoring. The Objective Force requirements of responsiveness, agility and versatility call for digitized graphical decision support interfaces that automate or otherwise help in various reasoning tasks. The main purpose of the paper is to describe the issues involved in building a diagrammatic reasoning system, specifications for a diagrammatic representation formalism, and an architecture for problem solving with diagrams. We have begun implementation of an application that infers maneuvers from data, obtained from an exercise at the National Training Center, about locations and motions of Blue and Red forces. We present algorithms used in the initial stages of an implementation.

Chandrasekaran, B., Josephsona, J., O'May, J., Heilman, E., & Kaste, R. (2004). Mining Simulation Data for Insights About a Decision Space: Application to an Urban Combat Coa. In In Proceedings of SPIE, Enabling Technologies for Simulation Science VIII, Dawn A. Trevisani and Alex F. Sisti, (Eds.), Bellingham, WA: SPIE. Vol. 5423 (pp. 32-42).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings decision architecture, data mining, course of action, combat simulation, planning, multi-criterial decisionmaking

Summary abstract:
We start with a vision of an integrated decision architecture to assist in the various stages and subtasks of decisionmaking. We briefly describe how the Seeker-Filter-Viewer (S-F-V) architecture for multi-criterial decision support helps realize many components of that vision. The rest of the paper is devoted to one of the components: developing insights about the course of action (COA) decision space from COA simulations. We start with data obtained from multiple simulation executions of an urban combat COA in a specified scenario, where the stochastic nature of different executions produce a range of intermediate events and final outcomes. The Viewer in the S-F-V decision architecture is used to make and visually test hypotheses about how sensitive different events and outcomes are to different aspects of the COA and to various intermediate events. The analyst engages in a cycle of hypothesis making, visually evaluating the hypothesis, and making further hypotheses. A set of snapshots illustrates an investigational sequence of abstractions in an example of iterating on hypotheses. The synergy of data mining tools, high performance computing, and advanced high-resolution combat simulation has the potential to assist battle planners to make better decisions for imminent combat.

Chandrasekaran, B., & Kurup, U. (2005). Augmenting Cognitive State with Diagrams. In In Proceedings of 2005 Soar Workshop. Ohio State University LAIR, Ann Arbor, MI.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
• Traditional AI/CogSci state representation (Soar, ACT-R) is "predicate symbolic."
• State change is accomplished by rule-based operators that transform the predicate symbolic representation. (Inference)
• Cognitive architectures such as SOAR should support an augmented notion of cognitive state
– Traditional "symbolic" will be one, generally dominant, component of state, but other perceptual and kinesthetic modalities need to be supported
– State change operations get more complex
– Diagrammatic representations make a good place to start because of their ubiquity and usefulness in problem solving

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Chandrasekaran, B., & Kurup, U. (2006). A Bimodal Cognitive Architecture: Explorations in Architectural Explanation of Spatial Reasoning. In In Proceedings of American Association for Artificial Intelligence (AAAI) Spring Symposium (www.aaai.org).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Research in Psychology often involves the building of computational models to test out various theories. The usual approach is to build models using the most convenient tool available. Newell has instead proposed building models within the framework of general-purpose cognitive architectures. One advantage of this approach is that in some cases it is possible to provide more perspicuous explanations of experimental results in different but related tasks, as emerging from an underlying architecture. In this paper, we propose the use of a bimodal cognitive architecture

called biSoar in modeling phenomena in spatial representation and reasoning. We show biSoar can provide an architectural explanation for the phenomena of simplification that arises in experiments associated with spatial recall. We build a biSoar model for one such spatial recall task – wayfinding, and discuss the role of the architecture in the emergence of simplification.

Chandrasekaran, B., Kurup, U., & Banerjee, B. (2005). A Diagrammatic Reasoning Architecture: Design, Implementation and Experiments. In In Proceedings of AAAI Spring Symposium, Reasoning with Mental and External Diagrams: Computational Modeling and Spatial Assistance, Stanford University, CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This paper explores the idea that the cognitive state during problem solving diagrams is bi-modal, one of whose components is the traditional predicate-symbolic representation composed of relations between entities in the domain of interest, while a second component is an internal diagrammatic representation. In parallel with the operators in the symbolic representation that are based on symbol matching and inferencing, there is a set of operators in the diagrammatic component that apply perceptions to the elements of the diagram to generate information. In addition there is a set of diagram construction operations that may modify the diagram by adding, deleting and modifying the diagrammatic elements, in the service of problem solving goals. We describe the design of the diagrammatic component of the architecture, and show how the symbolic and diagrammatic modes collaborate in the solution of a problem. We end the paper with a view of the cognitive state as multi-modal, in consonance with our own phenomenal sense of experiencing the world in multiple modalities and using these senses in solving problems.

Chandrasekaran, B., Kurup, U., & Banerjee, B. (2005). Representational and Inferential Requirements for Diagrammatic Reasoning in the Entity-Reidentification Task. In In Proceedings of 24th Army Science Conference. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Diagrammatic reasoning is ubiquitous in Army reasoning: situation understanding and planning in the Army both involve representing aspects of the situation and plans in the form of diagrams. We have been developing a general architecture to support diagrammatic reasoning for Army applications, and in an earlier report [1] we discussed an application in simple maneuver recognition. Our research strategy has been to investigate a variety of applications, each bringing additional requirements for perception and diagrammatic object creating capabilities that can assist the army. One such area is the army's All Source Analysis System (ASAS) that is designed to automate the processing and analysis of intelligence data from all possible sources. One of its purposes is to keep track of various enemy assets, based on a variety of sensors and reports, including direct sightings of entities. In order to maintain a coherent view, the system has to decide whether a new sighting refers to a new entity, a previously known entity that has since moved (re-identification) or is erroneous. This is the entity re-identification task. We have a built a system that uses an abductive reasoning process together with a diagrammatic reasoning system to solve this problem. In this paper, we look at some of the issues that the entity re-identification task poses for diagrammatic reasoning.

Chandrasekaran, B., & Yovtchev, T. (2007). A Qualitative Goms Approach to Evaluating Diagrammatic Interfaces. In In Proceedings of ICCM - 2007- Eighth International Conference on Cognitive Modeling. 205 - 210. Oxford, UK: Taylor & Francis/Psychology Press.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
We describe an approach to evaluating diagrammatic schemes intended to support problem solving and decision-making. The methodology is in the GOMS framework in HCI, and is based on recognizing that the use of diagrams is part of a process that can be decomposed into a sequence of steps, each of which may be a Perception on the diagram, Inference, Transformation of the diagram and Visual Search. How well a diagrammatic scheme helps in a task depends on how well the human cognitive architecture can perform the actions in the various steps, and how the steps collectively contribute to performance measures such as time, error rates, and memory stress. We illustrate the approach by using it to analyze the use of some common data presentation displays in the task of discovering interesting relations between variables in a domain. Because of the current lack of quantitative empirical data about the execution of the basic operations by human architecture, the analysis is qualitative, which is nevertheless useful in providing useful insights. It also sets an agenda for empirical research to obtain the quantitative data needed, since the availability of such data would help significantly in evaluating and improving diagrammatic interfaces for decision support.

Chen, D., Malkin, R., & Yang, J. (2005). Multimodal Detection of Human Interaction Events in a Nursing Home Environment. In In Proceedings of 6th International Conference On Multimodal Interfaces. State College, PA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Categories and Subject Descriptors
I.4.8 [Scene analysis]: motion, color, shape, tracking, stereo
General Terms
Algorithms
Keywords
Multimodal, human interaction, group activity, medical care,
stochastic modeling

Summary abstract:
In this paper, we propose a multimodal system for detecting human activity and interaction patterns in a nursing home. Activities of groups of people are firstly treated as interaction patterns between any pair of partners and are then further broken into individual activities and behavior events using a multi-level context hierarchy graph. The graph is implemented using a dynamic Bayesian network to statistically model the multi-level concepts. We have developed a coarse-to-fine prototype system to illustrate the proposed concept. Experimental results have demonstrated the feasibility of the proposed approaches. The objective of this research is to automatically create concise and comprehensive reports of activities and behaviors of patients to support physicians and caregivers in a nursing facility.

Christ, R. E., Alvah C. Bittner, J., Freeman, J. T., Archer, R., Klein, G., & Dyer, J. L. (2003). Training Rapid Decision-Making Processes Required by the Dismounted Objective Force Leader. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society. Denver, CO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The Army's Objective Force concept exploits the enormous opportunities made possible by advances in our capacity to quickly gather, organize, and distribute battlespace information. Electronic information systems will be developed and fielded to process and display critical features of the data available from multiple sensor and database systems. The Objective Force Warrior is one component of the Objective Force that encompasses a system of equipment and capabilities for the individual warfighter. This panel session is concerned directly with the use of these systems by the light, dismounted Infantryman. The Army clearly anticipates that innovative uses of advanced information systems will enhance the Infantryman's situational awareness and his decision-making capabilities.

Christoffersen, K., & Woods, D. D. (2002). Chapter 1. How to Make Automated Systems Team Players. In E. Salas (Ed.), Advances in Human Performance and Cognitive Engineering Research (Vol. 2, pp. 1-12). St. Louis, MO: Elsevier Science.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Advances in technology and new levels of automation have had many effects in operational settings. There have been positive effects from both an economic and a safety point of view. Unfortunately, operational experience, field research, simulation studies, incidents, and occasionally accidents have shown that new and surprising problems have arisen as well. Breakdowns that involve the interaction of operators and computer-based automated systems are a notable and dreadful path to failure in these complex work environments.
Over the years, Human Factors investigators have studied many of the "natural experiments" in human-automation cooperation - observing the consequences in cases where an organization or industry shifted levels and kinds of automation. One notable example has been the many studies of the consequences of new levels and types of automation on the flight deck in commercial transport aircraft (from Wiener & Curry, 1980 to Billings, 1996). These studies have traced how episodes of technology change have produced many surprising effects on many aspects of the systems in question.
New settings are headed into the same terrain (e.g. free flight in air traffic management, unmanned aerial vehicles, aero-medical evacuation, naval operations, space mission control centers, medication use in hospitals). What can we offer to jump start these cases of organizational and technological change from more than 30 years of investigations on human-automation cooperation (from supervisory control studies in the 1970s to intelligent software agents in the 1990s)?
Ironically, despite the numerous past studies and attempts to synthesize the research, a variety of myths, misperceptions, and debates continue. Furthermore, some stakeholders, aghast at the apparent implications of the research on humanautomation problems, contest interpretations of the results and demand even more studies to replicate the sources of the problems.

Coffey, J. W., Hoffman, R. R., Cañas, A. J., & Ford, K. M. (2002). A Concept Map-Based Knowledge Modeling Approach to Expert Knowledge Sharing. In In Proceedings of International Conference on Information and Knowledge Sharing.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Knowledge Elicitation, Knowledge Modeling, Knowledge Sharing, Concept Maps, PreSERVe Method

Summary abstract:
An important aspect of knowledge management is the implementation of methods to share the idiosyncratic knowledge of expert practitioners within an organization. In order to make such knowledge sharable, it is necessary to have both an effective elicitation method and a useful representation scheme. In this paper we describe the PreSERVe method of knowledge elicitation as it is used with a knowledge representation scheme based upon concept maps [1]. We describe the use of these methods in a case study on the capture and representation of local weather forecasting knowledge.

Cooke, N. J., & Chadwick, R. A. (2010). Chapter 19. Lessons Learned from Human-Robotic Interaction on the Ground and in the Air. In M. Barnes and F. Jentsch (Eds.), Human-Robot Interactions in Future Military Operations: Advanced Decision Architectures, Collaborative Technology Alliance.

Key Words:
ADA CTA

Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Unmanned or, more specifically, remotely-operated vehicles have contributed to the changing nature ofwarfare, and have taken center stage for civilian applications ranging from broader security and monitoring of wild fires, to search and rescue, and in surveillance o(disaster locations. Technological advances now make it possible for soldiers to use (unmanned combat aerial vehicles (UCAVs) to fight the enemy in the Middle East from a trailer in Nevada (Moran & Morris, 2006). It also makes it possible for search efforts to proceed in places too difficult for humans to enter, such as the Katrina-ravaged neighborhoods or the ruins of the World Trade Center, through the use of rescue robots (Murphy, 2004a, 2004b). These robotic vehicles have taken humans out of harm's way in situations known to be "dull, dirty, or dangerous."
Although the technology has progressed, it is not without setbacks. Remotely operated air vehicles have a high crash rate that has been attributed to early fielding of the technology, sensitivity to weather, and human factors concerns (Rash et aI., 2006; Williams, 2004). Similarly, ground vehicles have had a share of problems. Spatial disorientation is an inherent and consistently reported problem in the operation of ground vehicles (Chadwick & Pazuchanics, 2007; Tittle et aI., 2002). Poor reliability of search robots (Carlson & Murphy, 2003, 2004) and lack of adequate vehicle situated awareness (Riley & Endsley, 2004) continue to limit their usefulness.
Despite the presumed role ofhuman factors in the failure of these technologies, an aspect of the technology that has received minimal attention is the humanrobotic interface. This is often overlooked in lieu of a focus on the hardware and a tendency to "forget about" the operators who are located elsewhere (Cooke et aI., 2006b).

Cox, D. A., Ross, K. G., & Ross, W. A. (2005). Lightweight Synthetic Task Environments for C2 Research Experimentation In In Proceedings of 10th International Command and Control Research and Technology Symposium. Qu,bec City, Canada.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Force Transformation can be seen as a battle against complexity and uncertainty. This is especially true when we consider the less concrete components that are central to effective Command and Control (C2). Experimentation is the force we deploy in this battle as researchers (Alberts & Hayes, 2002). Our main force is large-scale experimentation and simulation. As with the main force in combat, the energy of experimentation can be squandered if not properly focused. Large-scale experimentation also has a large logistical tail, making it a precious resource in an era of increasing demands and restrictions. As such, we must be sure that it is deployed wisely, to maximum effect. In this paper we describe our lightweight Synthetic Task Environment (STE) concept and how it fits within the experimentation campaign framework. We report on our development and use of the lightweight STE concept. We describe the central construct, cognitive authenticity. We have set forward a process for creating STEs, and a framework for documenting their design. Further experience is needed to learn how to optimize the creation of STEs so that they can keep pace with force transformation efforts in the US Armed Forces.
STE Development Process
1. Develop research question
2. Investigate current or analogous performance
3. Select features to preserve or simplify
4. Review abstract design
5. Initial design of STE
6. Design review
7. Complete construction of STE
8. Pilot test

Cox, D. A., & Veinott, B. (2009). Developing Pattern Languages: New Ways of Communicating Naturalistic Insights for System Development and Evaluation In In Proceedings of Naturalistic Decision Making 9. London, UK.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Patterns, socio-technical systems, system evaluation, pattern language, representation

Summary abstract:
Motivation – The Naturalistic Decision Making (NDM) community benefits from having its insights used in software development projects.
Research approach – We are investigating the pattern form as a way to incorporate findings from naturalistic research into software development. The socio-technical level of description – how technology impacts groups, teams, and organizations – is the focus of our work.
Findings/Design – Pattern form offers the advantage of focusing interpretation and connecting to a solution outline over more traditional ways of making findings available. These advantages also make the pattern form good for use in the evaluation of systems where the need for solutions is immediate.
Research limitations/Implications – The pattern form is not a panacea and will not replace NDM participation in development projects.
Originality/Value – Patterns have not been used for evaluation at the socio-technical level.
Take away message – Patterns may be useful for communicating NDM insights in development projects, particularly those at the socio-technical level.

Cox, D. A., & Veinott, E. S. (2010). Ethno-Social Framework for Evaluation User's Guide.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Report

Summary abstract:
The focus on everyday expertise provided by the European sociological ethnographers of work practices, such as Heath and Luff (2000), provides a valuable complement to the other approaches taken (experimentation, CWA, CTA) in the Army Research Laboratory's Advanced Decision Architectures program. This work provides detailed descriptions of situated collaboration. We analyzed selected works of the European work ethnographers to identify recurring themes about how collaborative work is accomplished. Our aim was to identify these themes in a way that would be useful for early system evaluation.
We developed a preliminary tool that provides the initial identification of the kinds of alterations that may occur as a result of using a collaborative system based on existing ethnographic research and methods. This provided the initial data to develop a method for early reviews of collaborative tools in order to anticipate how a system might change individual behavior, team dynamics, and organizational workflow. Although this is a preliminary effort, because collaborative work is complex, can be distributed, and occur asynchronously, we feel this method has the potential to provide useful information for stakeholders in collaborative programs to evaluate the systems and developers of collaborative system to reduce misuses, and support emergent collaborative processes thereby improving transitions.
We identified seven themes: coordinate through close awareness of work progress, get attention while minimizing disruption, use gesture to coordinate conversations, support layers of context, arrange resources and practices for efficient communication, coordinate with the work rather than explicitly with others, and negotiate the work (Cox & Veinott, 2009). To conduct a face validity check on the themes we conducted data collection on the tool use in a highly collaborative, distributed, and sometimes asynchronous environment: natural disaster response. We interviewed 17 people in key roles for responding to the flooding in North Dakota that occurred in Spring 2009. We selected this incident due to its being widely viewed as an example of effective collaboration in emergency management and response. We conducted interviews with the North Dakota National Guard, civilian emergency managers (local and state), and volunteer coordinators. Our interviews focused on the nature of their collaborative work and the role of technology in support of collaboration (Veinott, Cox, & Zimmerman, in press). We compared data collected on Twitter™ during the 2007 San Diego wildfires (Cox & Veinott, 2009) to data to social media use during the North Dakota Floods.
This project has been successful in extracting from the work of the European sociological ethnographers themes that can be applied in system evaluation. Future research will extend the themes to cover more of the space of possible collaborative work arrangements, validate their explanatory and predictive power, and further demonstrate their utility for technical audiences.

Crandall, B., Klein, G., & Hoffman, R. R. (2006). Chapter 9. Trends and Themes in the Development of Cognitive Task Analysis: The Rise of Modern Cognitive Psychology, Working Minds: A Practitioner's Handbook of Cognitive Task Analysis. Cambridge, MA: MIT Press.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance

Summary abstract:
Cognitive Task Analysis as a set of methods (and a community of practice) began to emerge in the early 1980s. In this chapter, we describe the historical origins and more recent trends and influences that have culminated in CTA. Cognitive Task Analysis has roots in a number of disciplines. More than just a historical coincidence, the simultaneous emergence of CTA in a number of areas of science and applied research is a reason for its robustness. Understanding those multiple traditions provides an important perspective on CTA as a field of practice (Woods, Tinapple, Roesler, and Feil, 2002).
Many people assume that CTA emerged as a consequence of the rapid evolution of computer-based technology and the enormous changes in the workplace that have occurred in parallel In fact, CTA is deeply rooted in the history of psychology.
Beginning with the writings of John Watson (1914), the paradigm of behaviorism rose to prominence. It dominated American academic psychology for nearly half a century, despite arguments from within that the paradigm had significant limitations (e.g., Lashley 1951). But in the 1950s, the Carnegie Institute supported interdisciplinary meetings of linguists, psychologists, and computer scientists (Carroll 1953; Cofer 1979; Osgood and Sebeok 1954) that marked the "psychoIinguistic revolution." Among the champions of that revolution were Noam Chomsky, who presented notions of "generative transformational grammar" and criticisms of the behaviorist approach to language (Chomsky 1959).
Notions from World War II-era applied research also had an impact on psychology. Developments in audio-recording and signal-processing technologies led to significant advances in research on speech perception (e.g., Liberman, Delatre, and Cooper 1952). Information theory and signal detection theory (e.g., Shannon 1948) led to research on perception, attention, and vigilance.

Crandall, B., Klein, G., & Hoffman, R. R. (2006). Working Minds: A Practitioner's Handbook of Cognitive Task Analysis. Cambridge, MA: MIT Press.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book

Summary abstract:
1 Introduction
The value of experience and of understanding how to apply knowledge is described in a wonderful story, a story shared so often it has become one of those enduring urban legends. The story has many different 'versions', involving various professions and famous people. In one version of the story the scientist and inventor Nikola Tesla visited Henry Ford at his automobile factory. The factory was having some kind of difficulty with its systems, and Ford asked Tesla if he could help identify the problem area. Tesla \ . walked up to a wall of boilerplates, scanned them briefly, and then made an "X" in chalk on one of the plates. Examination of the boilerplate showed that it was indeed faulty. Ford was impressed, and told Tesla to send an invoice. The bill arrived, for $10,000. Ford, never known for his generosity, was astonished at the cost of writing an "X" on the boilerplate, and asked for a breakdown. Tesla sent another invoice, which read:
Marking wall: $1
Knowing where to mark: $9,999

This story speaks directly to the purposes and goals of this book in two respects. First, the story illustrates the "why" of Cognitive Task Analysis (CTA). What is it that Tesla knows, and how does he know it? What tells him what to do, with Henry Ford (not the most patient of men, by many accounts) looking over his shoulder? Capturing that knowledge and reasoning is one of the things CTA can do.

Second, the story illustrates the "how" of CTA. Cognitive Task Analysis can be thought of as a set of tools in a toolkit. Like any tool, CTA can be employed well and wisely, or it can be employed poorly or inappropriately. What tool would you use if you wanted to understand how Tesla was able to grasp the nature of the problem so quickly? This book is about having the tools and the toolkit to understand how people think: how their minds work, what they struggle with, and how they manage to perform. The book is organized into three major sections:

Part I, "Tools for Exploring Cognition in Context," provides detailed guidance for' planning and carrying out CTA. It includes chapters on capturing knowledge and on capturing the way people reason. We rely on this distinction throughout the book: CTA investigates what people know and how they think.

Part II, "Finding Cognition," provides a perspective on studying cognition in real-world settings and what an expanded view of cognition-a macrocognitive framework-offers. We describe some of the issues that surround CTA and what it means to study cognition in context. We end the section by exploring the challenges of rapidly changing technology.

Part III, "Putting CTA Findings to Use," describes key issues in applying CTA findings to several applications areas: technology development, .~raining and instructional design, and market research. We also present a chapter on the role of CTA in the development of measures for evaluating cognitive work.

Our intent in writing this book is to share what we have learned about CTA, from our experience in the field to the concepts and models we draw on. We have offered examples and suggested ways to apply CT A findings to real-world problems and issues. We hope this book provides you with some tools you can use in your own practice and that the CT A methods can help you discover how people like Tesla know where to put their chalk marks.

2 Overview of Cognitive Task Analysis Methods

We have reviewed many different approaches to CTA in order to show the possibilities that exist and to provide a context for the methods we describe in part I. Another reason for this overview is to demonstrate that there is no single right way to do CTA. Practitioners of CTA have a wide range of choices in the strategy to use in knowledge elicitation, data analysis, and knowledge representation. Instead of worrying about following an official program, practitioners are better served by tracking the cognitive phenomenon they want to understand. Getting an insightful account of this phenomenon is far more important than preserving methodological rigor that might interfere with the investigation.

Cognitive Task Analysis research is often conducted as field studies, since it com~ prises the initial exploration of a cognitive process or strategy that is not well understood. We argue that it is misplaced rigor-rigor mortis, in fact-to let the choice of methods overshadow the phenomenon being studied. For field research, scientific values dictate that the methods you employ be documented and that your analyses be described in sufficient detail so that others can review your efforts and replicate your findings. You will also want to document evidence that runs counter to your hypotheses. These are all appropriate measures to increase scientific validity. In contrast, a rigid adherence to experimental control during a CTA study is an inappropriate attempt to mimic the psychology laboratory.

Therefore, we recommend that CTA researchers be prepared with a range of methods that they can use or adapt. Researchers have many choices in the strategy they use in knowledge elicitation, data analysis, and knowledge representation. The remainder of this book, in a sense, is aimed at providing enough information . so that researchers can make those choices.

I. Tools for Exploring Cognition in Context

3 Preparation and Framing

This chapter described activities that provide the initial preparation for a successful CTA project. A set of framing questions were presented that can provide important insights and guidance throughout the entire project. Answers to the framing questions will result in some ideas and initial decisions about:

- the issue or need that the research will address,
- the kind of deliverable or product that will result,
- the kinds of individuals who might be best as "target users" or "informantcollaborators,"
- the aspects of cognition or expertise that must be revealed,
- the kinds of research settings that might be most appropriate to the project goals, and
- the kinds of individuals who would be the best participants in the CTA procedures.

The chapter also provided guidance about how to work with task-function descriptions that may already exist and ways to come up to speed and learn about the domain.

4 Using Concept Maps for Knowledge Elicitation and Representation
CTA involves capturing what practitioners know about their domain: its concepts, principles, and events. We can think of no CTA process or project in which the CTA researchers did not have to elicit and then represent at least some domain knowledge. This chapter reviews the procedures and applications of Concept Mapping as a proven knowledge elicitation method for the efficient elicitation of practitioner knowledge. Concept Maps involve labeled nodes and links, but Concept Maps differ in important ways from other types of diagrams that utilize combinations of graphical and textual elements to represent or express meanings. Concept Mapping supports the practitioner's effort to reach for crystal clarity about what he or she wishes to express. In Concept-Mapping knowledge elicitation, the researchers help the domain practitioner build up a representation of domain knowledge, in effect merging the activity of knowledge elicitation and the activity of knowledge representation.

5 Incident-Based CTA: Helping Practitioners "Tell Stories"
In this chapter, we described one method for using incidents to extract cognitive elements-the Critical Decision Method. We described the procedures for conducting a CDM interview and offered an interviewer's perspective on each of the CDM components. We examined the boundary conditions under which CDM is less likely to be effective, and we described some of the variations and adaptations that have developed to take advantage of the data collection opportunities that real, lived experience offers.

6 CTA Methods and Experiment-Like Tasks
In this chapter we explored some intersections of laboratory methods and field research methods for conducting CTA. Researchers can tinker with aspects of a familiar task in a variety of ways, thereby eliciting experts' strategies and reasoning, and do so in structured ways that provide empirical leverage. We also discussed think-aloud problem-solving and protocol methods and the use of analytic and representational formats that can reveal important aspects of cognitive process.

7 Analysis and Representation
The intent in this chapter has been to open the "black box" of analysis and representation, and examine the processes and procedures that can be used to transform specific data elements to general findings. Reading about CTA is likely to lead to an impression that knowledge elicitation activities constitute the entire CTA process and that once the data have been gathered one can move easily, with little time or effort, into application of the findings. For a number of CTA techniques, the knowledge elicitation methods do produce a data structure and populate it. In some methods, such as concept mapping or the simulation interview in ACTA, knowledge elicitation and knowledge representation are inherently linked. But these techniques still produce representations on an individual level, specific to a particular SME, simulation, or event. They do not circumvent the necessary steps of integrating and synthesizing data, extracting meaning, and identifying key findings. How those activities are carried out, and how findings and applications link back to individual data elements, requires consistent attention and clear explanation.

II. Finding Cognition
8 Thinking About Cognition
In this chapter we explored what it means to study cognition in natural contexts and how that differs from the study of cognition in a laboratory. We described a cognitive landscape that includes aspects of expertise. This perspective helps to uncover subtle aspects of cognition in real-world contexts. The cognitive landscape includes macrocognition-the cognitive functions and processes that emerge when the research focus shifts to natural contexts. We discussed how field studies of cognition and appropriate use of qualitative methodologies meet the criteria for scientific inquiry. These topics matter because there is more to CTA practice than knowledge of CTA tools and techniques. The best CTA practitioners spend time learning about cognitive elements of performance in order to understand a wide range of cognitive phenomena. By understanding the way people think and reason in natural contexts, CTA practitioners are more likely to recognize important aspects of cognition when they encounter them.

9 Trends and Themes in the Development of Cognitive Task Analysis: The Rise of Modern Cognitive Psychology
In this chapter we explored the historical roots of CTA. Academic research traditions and trends in applied research have each contributed to the development of CTA methods. Reaction against the dominance of behaviorism in North American psychology led researchers to a renewed interest in understanding cognitive processes. This was

accelerated by the advent of information theory and computer metaphors of mind. In parallel, the impact of technology in the workplace prompted applicationoriented researchers to explore a wider array of complex social-technological influences. The confluence of factors produced a wave of interest in cognitive work and led researchers in a number of communities of practice to discuss what have come to be called CTA methods.

10 Information Technology
In designing and introducing new types of IT, there are many decisions to be made about how people will work with the technology-how they will coordinate with it, what roles the technology will play, and how to allocate functions between people and technology. In this chapter we described some of the challenges and opportunities that arise when IT is introduced to help people perform tasks and some of the cognitive demands that are created by IT.

III. Putting CTA Findings to Use
11 The Role of Cognitive Requirements in System Development
In this chapter, we examined some specific ways to use CTA to generate cognitive requirements for system development and design. We presented a particular approach, DCD, in order to illustrate and describe some general principals of cognitive engineering. Information technology offers enormous potential for improving decision making, but only if the developers of technologies take cognitive requirements into account, not just at the test and evaluation stage, but throughout the development and procurement process.

12 Cognitive Training
CTA is central to cognitive training. Uyou want to improve cognitive functions such as decision making, sensemaking, problem detection, replanning, and so forth, you will need to understand how these functions are accomplished and where people struggle and run into difficulties. In this way, you can define cognitive training requirements.
The primary applications of CTA for cognitive training are to identify and define the training requirements, discover the basis of skills, the source of difficulties, collect incidents that can be transformed into training scenarios, and guide the feedback process to help trainees learn from their experiences.
One question we are often asked is about the relationship between cognitive skills training based on CTA and more traditional training approaches such as instructional systems design (lSD). ISD typically has been used for procedural tasks; so cognitive skills training could complement ISD by providing a cognitive perspective. However, specifying the cognitive functions has the potential to make ISD more cumbersome and harder to use. Critics of ISD (e.g., Gordon and Zemke 2000) see the ISD approach as already being unwieldy, and inefficiently carving the world into too many small slices. Adding the cognitive dimension could make ISD even more so by overlaying all the procedural objectives with cognitive ones.
CTA efforts should result in richer training objectives, not longer lists of objectives. We do not see the decision requirements as a discrete set of training objectives. Rather, they are different facets of performing the cognitive work. Training developers would not want separate modules, say, for problem detection skills and sensemaking skills.• The same scenarios should be training sensemaking and problem detection and decision making. The design process in cognitive training aims at providing experiences that permit trainees to explore, reflect, learn, work through confusion, and develop deeper and richer mental models for carrying out complex tasks.

13 Understanding How Consumers Make Decisions: Using Cognitive Task Analysis for Market Research
Market researchers are primarily interested in figuring out how to influence consumer behavior. Conventional approaches to market research have pursued that goal by studying consumer behavior, attitudes, deSires, and beliefs. Although all this information is valuable and important, it does not address the critical component of consumer cognition: what consumers know, how they think, and what strategies they have developed for buying and using products. This chapter explored ways in which CTA methods can be applied to market research questions. Cognitive Task Analysis methods can reveal the strategies consumers use to make the purchase decision-whether to purchase a particular product, which brand to select, which features to choose, or whether to try a different brand with different features altogether. Cognitive Task Analysis methods can explain how users understand what products do and how they work, and can offer insights about why consumers may not use products in the ways that their developers intend. Finally, CTA methods can reveal the skills and the gaps in understanding that front-line sales staff may have regarding their customers.

14 Cognitive Task Analysis for Measurement and Evaluation

Measurement of various kinds and combinations is critical in shaping CTA, conducting CTA, and going from CTA results to conclusions and recommendations. Cognitive Task Analysis methods are well suited to identify cognitive requirements and to support the creation and application of cognitive measures to study macrocognitive functions. With the growing use of information technologies, developers need to determine how their systems are affecting cognitive processes. Cognitive measures are relevant to software support systems. Cognitive measures are also needed with the variety 'of training programs aimed at improving decision making and other macrocognitive functions. We invite all of these communities to borrow and apply CTA probes and methods as they find practical. Practitioners may want to conduct CTA studies, or they may just need to tap into cognitive requirements in a piecemeal fashion. Whichever is the case, deploying CTA methods in the evaluation process should help produce results that lead to better system performance.

15 Future Directions for Cognitive Task Analysis
We hope that throughout the reading of this book you have learned some useful methods along with some effective ways of implementing these methods. We have tried to describe our trade secrets, to help you understand various CTA methods and to give you the courage to explore new approaches to gathering data. We have tried to show the depth, richness, and value of CTA and its applications. As you can see, there are no hidden mysteries, only hard work and practice, as with mastering all complex skills.

Appendix
- The Interview
• Establish rapport with the participant
• Know how to use time to greatest impact-when to spend time on a topic and when to move on
• Ask good opening questions: they know what they want and how to get it efficiently
• Recognize where to drill down, what to deepen on; they can hear words or phrases that flag rich areas for probing
• Recognize when a direction is not fruitful: they can tum the interview around and get it going in a productive direction
• Recognize how to frame questions: how to pose a question so that it makes sense but doesn't lead the interviewee
• Recognize where the important content is likely to be and how to bring the interview to that place (this may require a whole series of questions that set up a key insight)
• Know how to reorient the interview when the current direction isn't working
• Have a range of strategies for probing, deepening into content
• Understand the power of silence: they can wait for the interviewee to think about a question without filling the void with talk

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Cuevas, H. M., Fiore, S. M., Caldwell, B. S., & Strater, L. (2006). Augmenting Team Cognition in Human-Automation Teams Performing in Complex Operational Environments. Special Supplement on Operational Applications of Cognitive Performance Enhancing Technologies for the journal Aviation, Space, and Environmental Medicine.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
automation technology, human-automation interaction, intelligent agents, semi-autonomous robots, team coordination, cognitive processes, metacognitive processes

Summary abstract:
There is a growing reliance on automation (e.g., intelligent agents, semi-autonomous robotic systems) to effectively execute increasingly cognitively complex tasks. Successful team performance for such tasks has become even more dependent on team cognition, addressing both human-human and human-automation teams. Team cognition can be viewed as the binding mechanism that produces coordinated behavior within experienced teams, emerging from the interplay between each team member's individual cognition and team process behaviors (e.g., coordination, communication). In order to better understand team cognition in human-automation teams, team performance

models need to address issues surrounding the effect of human-agent and human-robot interaction on critical team processes such as coordination and communication. Toward this end, we present a preliminary theoretical framework illustrating how the design and implementation of automation technology may influence team cognition and team coordination in complex operational environments. Integrating constructs from organizational and cognitive science, our proposed framework outlines how information exchange and updating between humans and automation technology may affect lower-level (e.g., working memory) and higherlevel (e.g., sense making) cognitive processes as well as teams' higherorder "metacognitive" processes (e.g., performance monitoring). Issues surrounding human-automation interaction are discussed and implications are presented within the context of designing automation technology to improve task performance in human-automation teams.

Cuevas, H. M., Strater, L., Caldwell, B. S., & Fiore, S. M. (2007). Team Cognition in Human-Automation Teams. In In Proceedings of K.Mosier & U. Fischer (eds.), Proceedings of the Eighth International Conference on Naturalistic Decision Making.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Team cognition, human-automation interaction, attitudes toward automation

Summary abstract:
Technological advances have significantly intensified the challenges facing teams performing in today's operational environments (e.g., nuclear power plants, military battlefield, long duration space flight), leading to a growing reliance on automation (e.g., intelligent agents and semi-autonomous robotic systems) to support and enhance team performance in increasingly complex cognitive tasks. Integrating constructs from organizational and cognitive science, we describe a theoretical framework illustrating how the design and implementation of automation technology may influence team cognition and decision making. We also discuss the results of a preliminary study, conducted in a military command and control environment, aimed at exploring components of our theoretical framework, specifically focusing on the attitudinal variables (human operators' attitudes toward automation) that may influence human-automation interaction.

Davis, J. W., Morison, A., & Woods, D. D. (2007). Building Adaptive Camera Models for Video Surveillance. In In Proceedings of IEEE Workshop on Applications of Computer Vision. Austin, TX.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings; Video Surveillance

Summary abstract:
We address the limited automatic scanning functionality of standard PTZ camera systems. We present an adaptive, scene-specific model using standard PTZ camera hardware. The adaptive model is constructed automatically by detecting human activity in Motion History Images (MHIs) using an iterative candidacy-classification-reduction process. The target motion is quantified and employed in the construction of a global Activity Map, which in turn is used to direct or navigate the camera.

Davis, J. W., Morison, A. M., & Woods, D. D. (2007). An Adaptive Focus-of-Attention Model for Video Surveillance and Monitoring. Machine Vision and Applications Journal, 18(1), 41–64.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Computer vision · Machine vision ·
Motion detection · Surveillance · Security · Camera

scanning · Motion history images

Summary abstract:
In current video surveillance systems, commercial pan/tilt/zoom (PTZ) cameras typically provide naive (or no) automatic scanning functionality to move a camera across its complete viewable field. However, the lack of scene-specific information inherently handicaps these scanning algorithms. We address this issue by automatically building an adaptive, focusof- attention, scene-specific model using standard PTZ camera hardware. The adaptive model is constructed by first detecting local human activity (i.e., any translating object with a specific temporal signature) at discrete locations across a PTZ camera's entire viewable field. The temporal signature of translating objects is extracted using motion history images (MHIs) and an original, efficient algorithm based on an iterative candidacy- classification-reduction process to separate the target motion from noise. The target motion at each location is then quantified and employed in the construction of a global activity map for the camera. We additionally present four new camera scanning algorithms which exploit this activity map to maximize a PTZ camera's opportunity of observing human activity within the camera's overall field of view. We expect that these efficient and effective algorithms are implementable within current commercial camera systems.

Dekker, S. W. A., Nyce, J. M., & Hoffman, R. R. (2003). From Contextual Inquiry to Designable Futures: What Do We Need to Get There? IEEE Intelligent Systems, 18(2), 74077.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
So, what is an end user, really? And what do we really mean by the procurement process? Human factors researchers often take certain agendas, terms, and theories for granted or rely on them out of habit. This essay takes a special look at contextual enquiry as a putatively (and indeed potentially) superior way of giving end users a serious say in the procurement process of complex cognitive systems.

Dekker, S. W. A., & Woods, D. D. (2003). Maba_Maba or Abracadabra? Progress in Human-Automation Coordination. Cognition, Technology, and Work, 44(4), 240-244.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Automation; Cognition; Computers; Co-ordination; Function allocation; Human error

Summary abstract:
In this paper we argue that substitution-based function allocation methods (such as MABA-MABA, or Men-Are-Better-At/Machines-Are- Better-At lists) cannot provide progress on human–automation co-ordination. Quantitative 'who does what' allocation does not work because the real effects of automation are qualitative: it transforms human practice and forces people to adapt their skills and routines. Rather than re-inventing or refining substitution-based methods, we propose that the more pressing question on human–automation co-ordination is 'How do we make them get along together?'

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dePontbriand, R. J., Woods, D., Schultz, A. C., Archer, S., Endsley, M., & Scholtz, J. (2003). Discussion Panel: Human Robot Coordination. Intent at a Distance; Dynamic Level of Autonomy; Soldier Performance Assessment for Control of Multiple Unmanned Systems; Task Interruption When Interacting with Robotic Systems; Supporting

Situation Awareness in Humanrobot Collaboration; Evaluation of Human-Robot Collaboration. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society. Denver, CO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In recent years, accelerating maturation of robotics technologies, such as machine perception and intelligent control technologies have led to a widening knowledge and experiential base serving as a springboard for expanded research.
This maturation has led to increased engineering reliability, opening the way for more tractable human-robot research. The technology area from which a good deal of this work can draw inspiration and guidance is humans in automation (Parasuraman, Sheridan and Wickens, 2000), which lets us examine issues including air traffic controllers' multitracking or pilots' multi-tasking operations under conditions of time and other stressors. Among the issues the panelists will address are: How will human-robot teams dynamically reconfigure or gracefully degrade as assets are lost? How can people and robots make judgments of the robots ability to traverse or climb broken terrain? How can people manage multiple robots? How can robots and people build a shared awareness of the remote environment? What metrics will capture human-robot teamwork? Overall, human-robot team work is a new frontier for Human Factors.

Diesner, J., & Carley, K. (2009). Looking under the Hood of Stochastic Machine Learning Algorthms for Parts of Speech Tagging. In In Proceedings of Conference at Carnegie Mellon University, School of Computer Science, Institute for Software Research, Technical Report CMU-ISR-08-131R.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Part of Speech Tagging, Hidden Markov Models, Viterbi Algorithm, AutoMap

Summary abstract:
A variety of Natural Language Processing and Information Extraction tasks, such as question answering and named entity recognition, can benefit from precise knowledge about a words‟ syntactic category or Part of Speech (POS) (Stolz, Tannenbaum et al. 1965; Church 1988; Rabiner 1989). POS taggers are widely used to assign a single best POS to every word in text data, with stochastic approaches achieving accuracy rates of up to 96 to 97 percent (Jurafsky and Martin 2000). When building a POS tagger, human beings needs to make a set of decisions, some of which significantly impact the accuracy and other performance aspects of the resulting engine. In this paper we provide an overview of these decisions and empirically determine their impact on POS tagging accuracy. We envision the gained insights to be a valuable contribution for people who want to design, implement, modify, fine-tune, integrate, or simple reasonably use a POS tagger. Based on the results presented herein we built and integrated a POS tagger into AutoMap, a tool that facilitates Natural Language Processing and relational text analysis, as a stand-alone feature as well as an auxiliary for other tasks.

Diesner, J., & Carley, K. M. (2008). Conditional Random Fields for Entity Extraction and Ontological Text Coding. Journal of Computational and Mathematical Organization Theory, 13, 248-262.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Ontological Text Coding · Semantic networks · Entity Extraction ·
Supervised machine learning · Conditional models · Conditional Random Fields

Summary abstract:

Previous research suggests that one field with a strong yet unsatisfied need for automatically extracting instances of various entity classes from texts is the analysis of socio-technical systems (Feldstein in Media in Transition MiT5, 2007; Hampe et al. in Netzwerkanalyse und Netzwerktheorie, 2007; Weil et al. in Proceedings of the 2006 Command and Control Research and Technology Symposium, 2006; Diesner and Carley in XXV Sunbelt Social Network Conference, 2005). Traditional as well as non-traditional and customized sets of entity classes and the relationships between them are often specified in ontologies or taxonomies.We present a Conditional Random Fields (CRF)-based approach to distilling a set of entities that are defined in an ontology originating from organization science. CRF, a supervised sequential machine learning technique, facilitates the derivation of relational data from corpora by locating and classifying instances of various entity classes. The classified entities can be used as nodes for the construction of socio-technical networks. We find the outcome sufficiently accurate (82.7 percent accuracy of locating and classifying entities) for future application in the described problem domain. We propose using the presented methodology as a crucial step in the process of advanced modeling and analysis of complex and dynamic networks.

Diggelen, J. v. (2009). Fulfilling Collective Obligations in Human-Agent Teams Using KAoS Policies. In In Proceedings of Workshop on Rich Cognitive Models for Policy Design and Simulation, Lorentz Center, Leiden, The Netherlands.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Autonomous agents
• A key property of agents is autonomy, meaning that they can operate on their own without the need for external guidance
• Research on autonomy has focused on endowing an agent with control over its own actions and internal state
• Systems that consist of autonomous agents are particularly suited to implement open systems, heterogeneous systems, complex systems

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Dominguez, C., Cox, D., William G. Long, Moon, B., & Klein, G. (2005). Helping Analysts Deal with Data Overload: Profiling Profilers. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Intelligence analysts provide an incredibly important service toward maintaining our national security. They are chartered with providing the knowledge basis for decisions our national and military leaders make. Analysts must be depended upon to influence high-risk, time-critical, sometimes life-or-death decisions; thus, supporting their requirements is a vital goal for research and development efforts. In this paper, we focus on the cognitive aspects of analysts' information collection and filtering tasks, particularly of all-source analysts who continuously monitor message traffic. These analysts create synthesized reports for customers. We will discuss the issue of data overload and its effects, along with current lines of research on information retrieval. We end with a summary of our research effort examining filtering/profiling, to include approach and initial findings, towards our eventual goal of developing design seeds that can be incorporated into software tools to better support analysts' cognitive work.

Dominguez, C., Uhlig, P., Brown, J., Gurevich, O., Shumar, W., Stahl, G., Zemel, A., & Zipperer, L. (2005). Studying and Supporting Collaborative Care Processes. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In patient care today, teams of practitioners from various disciplines must coordinate their efforts in order to deliver care successfully. Frontline nurses and physicians must interact with social workers, therapists, physician assistants, nurse practitioners, and others to develop and carry out coordinated plans of care. Also, clinical team members must communicate with patients and their families in language that can be understood and acted upon. In support of these goals, JCAHO standards require patient care to be planned and provided in an interdisciplinary, collaborative manner. As hospital units develop processes for collaborative care in complex environments such as post-surgery and critical care units, it is important to understand what constitutes success for these processes and how they can be enabled and supported. This report documents a series of field visits and simulations designed to observe, videotape, and interview collaborative care team members, patients, and family members engaged in varying forms of collaborative practice. This ongoing research is being conducted by a multi-disciplinary team of medical and social scientists with a shared goal of studying and supporting collaborative care processes.

Donnelly, J., Madden, J., Roberts, A., Greenberg, M., Bradshaw, J., & Uszok, A. (2007). Dynamic Policy Enforcement in Jbi Information Services with the KAoS Policy and Domain Services. In In Proceedings of SPIE Defense and Security Symposium, Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings dynamic policy enforcement, information management, JBI, KAoS, ontology, OWL

Summary abstract:
English-language policies about the desired behavior of computer systems often suffer from translation errors when implemented with a proliferation of low-level rules governing access control, resource allocation and configuration. To solve this, Dynamic Policy Enforcement systems replace these low-level rules with a relatively small number of semantically grounded, machine-understandable policy statements. These statements use domain terms defined in an ontology that are formally defined so that they can be enforced by the system but also meaningful to human administrators to ensure that they accurately represent organizational policies. In this paper, we describe the application of one such Dynamic Policy Enforcement system, KAoS, to the control of distributed, information-management services defined by the Air Force Research Laboratory's Joint Battlespace Infosphere (JBI) program. Our research allows administrators to define the desired behavior of the participants in the system, both human and software, with one collection of well defined policies. As a result, a single set of tools for the definition, analysis, control, and monitoring of policy can be used to implement access control, service configuration, and service delivery prioritization.

Eccles, D. W., Feltovich, P. J., & Hoffman, R. R. (2003). Modeling Terrain Analysis Expertise to Support Command and Control (C2) in the Field. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures

Summary abstract:
This report describes: (1) a process for capturing the knowledge of military experts, and (2) the use of models of that expert knowledge in a revolutionary re-design of military field manuals and other documents, transforming them into a new type of knowledge resource that "takes the expert into the field." The project focused on expertise at terrain analysis after it was realized that coping with terrain is the mostfrequently cited source of difficulty in C2 activities. The development process involved identifying experts at the US Army Corps of Engineers and then conducting Cognitive Task Analysis (CTA) procedures in order to elicit their knowledge. What resulted was a corpus of thousands of propositions concerning terrain (soils, rock types, drainage patterns, etc.), referred to as the Terrain Analysis Data Base (Hoffman, 1984). The TADB has existed only in the form of a text document. Our work

for the CTA Program involved a new process called "knowledge recovery," in which expertise that is latent in text formats can be recovered and placed into new formats making that expertise more accessible and usable. Using the CmapTools software, we created over 100 Concept Maps, which included all of the propositions in the TADB. Next, the textual information in the "Army Field Manual for Terrain Analysis" (Department of the Army, 1990) was cut into meaningful units and these were hyperlinked to the concept nodes in the Concept Maps. The resulting knowledge model, "Representation of Conceptual Knowledge–Terrain Analysis" (ROCK-TA) represents expert-level knowledge about terrain, recaptured from older text documents and placed into an electronic form that can be taken into the battlefield context. Used in conjunction with GIS-based map information, ROCK-TA can be used by commanders at the "Unit of Action" level, or planners at the Battalion level who are engaged in intelligence preparation of the battlefield. The system should support the evaluation of terrain for such things as trafficability, line of sight, cover & concealment, and engineering properties. Furthermore, ROCK-TA is a living e-document that can be continually updated with new information about terrain and expert reasoning about terrain. We are currently exploring the possibility of using the Concept Map format to re-design Army Operation Orders, also to make them more useful in the battle context than traditional text by making the information they contain more readily accessible.

Eckroth, J., Reddy, D., Josephson, J. R., Chellappa, R., & Miller, T. N. (2009). Chapter 2. From Background Subtraction to Threat Detection in Automated Video Surveillance. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section I. Collecting, Processing and Distributing Battlefield Information: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
As video cameras and other sensors become cheaper and easier to network, sensor networks become increasingly attractive means to acquire useful information for military operations, such as video surveillance for facilities protection, and "persistent surveillance" to maintain sensory contact with targets of interest. However, without assistance from automation, humans will be overloaded by information, and unable to use it effectively.
"What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention, and a need to allocate that attention efficiently among the overabundance of information sources that might consume it."
It is difficult for humans to vigilantly monitor a large number of video feeds for extended periods without fatigue, or complacency, especially if they are asked to recognize the significance of rare events in a complex stream of events. Moreover, sometimes events of interest cannot be recognized simply from the video without knowing where a specific camera is pointing, at a restricted area, for example. Keeping track of the location and significance of a camera's field of view imposes an additional cognitive burden. The cognitive burden is even greater if recognizing events of interest requires tracking entities as they become visible in different cameras, and accessing mental maps to understand the significance of motion paths.
Automation can help. It can potentially provide users with alerts based on recognizing indicators of threatening behavior, including behavior that cannot be detected with a single camera. For example, the movement of an entity from place to place in relation to the map might show a pattern indicative of scouting the perimeter of a facility, where no single camera view shows anything suspicious. Many unsolved technical problems remain, however, including problems about how to extract needed information from video imagery, and problems of how to process acquired information to climb the levels of abstraction from individual camera-centered frameworks to a world-centered framework, and from motion description ("Object 05604 moved along path P52 from location L12 at time T 55 to L13 at T 66"') to behavior description (,,05604 proceeded slowly north on road R3 to the intersection with R7, turned East on R7 .... ") to recognition of indicators of threat ("°5604 slowly circled the facility:'). .
Abundant video also threatens to overload communications and storage systems. Typically, the sensed bits are highly redundant for the task to be performed. For example, when it is important to track a moving object, the

important information is which part ofthe image is changing continuously. To understand which region is relevant, subtraction of the unchanging background is needed, and if it can be performed at the sensor itself, significantly fewer bits need to be transmitted. Accordingly, a new framework can be envisaged in which the traditional ways of sensing an image (in rectangular pixels) are replaced by sensing the image information in a compact form ("compressed sensing"), and then reconstructing the required image, as needed, from this compact information. This paper describes some elements of recent progress in technology for video surveillance that specifically address methods for background subtraction to detect changes from frame to frame in video, tracking of viewed objects in camera-centered "image space," tracking of objects in world oriented "object space" using information from mUltiple cameras, and methods for "climbing" levels of abstraction in descriptions of behavior.

Elm, W., Potter, S., Tittle, J., Woods, D., Grossman, J., & Patterson, E. (2005). Finding Decision Support Requirements for Effective Intelligence Analysis Tools. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Within ARDA's GI2Vis program, we developed a unique framework for the definition of decision support requirements for intelligence analysis tools. This framework, based on a first-of-a-kind integration of a model of inferential analysis and principles for designing effective human-computer teams from Cognitive Systems Engineering, has defined the essential support functions to be provided to the intelligence analyst(s). This model has proven to be extremely useful in assessing the support provided by a large set of visualization tools. This assessment has identified clusters of support functions that are addressed by many tools as well as key missing support functions. In this way, the Support Function Model has been used to identify gaps in the support function coverage of existing tools. This can serve as a valuable focusing mechanism for future design and development efforts. In addition, we believe this would be a useful mechanism to enhance cross-discussions among research teams involved in Cognitive Task Analysis efforts within the Intelligence Community. Having others integrate their analytic results with this framework would provide the mechanism for expansion of this model to become a more robust tool and have an even greater impact on the Intelligence Community.

Elm, W. C., Woods, D. D., Bennett, K., Bisantz, A., Eggleston, R., & Mitchell, C. (2002). Behind the Curtain: The Cognitive Tasks Behind the Visualizations (Representational Types for Effective Visualization Design) (Discussion Panel). In In Proceedings of 46th Annual Meeting of the Human Factors and Ergonomics Society. Baltimore, MD.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This panel includes participants from academia and industry who have each made significant contributions to the design of effective visualizations to support decision making in a variety of domains. Panel members will offer an example of an innovative decision support visualization concept and discuss the underlying cognitive demands it is meant to support as well as any artifacts they used in its development. Both the nature of the visualization itself, and the linkage to the processes 'behind the curtain' will be presented. Panelists will discuss the various techniques used and the pro's and con's of each.

Endsley, M., & Hoffman, R. R. (2003). The Sacagawea Principle. IEEE Intelligent Systems, November, 80-85.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Many software tools and systems restrict the availability of information and make information integration and exploration difficult. Poorly designed tools are often brittle, because they prescribe task sequences. But in complex sociotechnical contexts, workers do not perform tasks; they engage in knowledge-driven, context-sensitive choices from among action sequence alternatives in order to achieve goals. So, good tools must be flexible—they must provide the information that workers need to generate appropriate action sequences by which they can achieve the same goal in different situations. Adapted from the writings of Donald Norman is a principle we call the Sacagawea Principle:

Human-centered computational tools need to support active organization of information, active search for information, active exploration of information, reflection on the meaning of information, and evaluation and choice among action sequence alternatives.

Context-conditional variation includes variation due to the worker—each worker has his or her own needs, entailing different requirements and constraints. This implies that individuals should be able to choose different trajectories to achieve the desired outcome in different ways. A good tool gives users discretion to generate various action sequences and express their preferences.
As with many HCC principles, we have named this one after a person to give it a concrete and meaningful label. Sacagawea served as a guide, without whose help the Lewis and Clark expedition might not have achieved the successes it did. The name is also somewhat ironic, because Sacagawea was, for part of her life, a captured slave. The theme of machines and robots as slaves is arguably the oldest in the robotics literature, and it is still often used as a metaphor to describe the tools people use to accomplish their work. In this essay, we explore an approach for fulfilling the Sacagawea Principle in system design—an approach based on empirical study of the way in which people process their environments in complex worlds.

Endsley, M. R. (2001). Designing for Situation Awareness in Complex Systems. In In Proceedings of Second International Workshop on Symbiosis of Humans, Artifacts and Environment. pp. 176-190. Kyoto, Japan: Program of the Japan Society for the Promotion of Science.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
We are living in what has been termed the "information age". In many domains, this has meant a huge increase in systems, displays and technologies. From voice control to sophisticated line of sight head mounted displays, almost anything is possible in today's world, but too much is proving to be as big a challenge as too little once was. The problem is no longer lack of information, but finding what is needed when it is needed.
This problem is not isolated to cockpits or power plants. All around us, signs of this change are present. Whether you are working on the shop floor, in the world of business, or just trying to purchase a new computer for your home, the dizzying pace of technological change and vast amount of information present can be daunting. We are constantly being barraged with information through TV, radio, mailings and hundreds of magazines and journals. Within our companies, reports and forms have multiplied and every aspect of the business is recorded somewhere. Bringing all of this information together in a form that is manageable is quite a challenge. There is simply more information than anyone can handle.

Endsley, M. R. (2003). Breaking through the Data Glut: Bringing to Light the Meaning of Information. HSIAC Gateway. XIII (4), p. 7.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Today, it is possible to gather and trans¬mit vast quantities of data. However, this unprecedented access to data has failed to produce hoped for leaps in understanding because there is a huge gap between the glut of data produced and disseminated and users' abilities find and process the information they real¬ly want amongst all that is possible. This gap challenges many in positions crucial to security and homeland defense—the intelligence analyst who may read thousands of messages to unearth a terrorist plots, an American soldier who must integrate and coordinate the activities of widely distributed units in a foreign country surrounded by hostile combatants as well as civil¬ians, and millions who need to be able to detect information attacks by hackers. Just as information is a tool in our arsenal, it also serves as a tool of those who seek to undermine the U.S. and its institutions.

Endsley, M. R. (2003). Macro-Cognition: Directions at the Crossroads. In In Proceedings of 6th International Conference on Naturalistic Decision Making. Pensacola Beach, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Macrocognition has been defined as a description of cognitive functions in natural decision making settings (Cacciabue & Hollnagel, 1995). As such, it has much in common with other terms or bodies of study including situated cognition, naturalistic decision making and cognitive engineering. All of these approaches have recognized the importance of context in understanding human cognition and behaviors, mostly as a rejection of the sterile, laboratory-based cognitive research of more traditional psychology endeavors. As such, they signify a different research paradigm, with different goals and objectives from microcognitive approaches. Understanding the cognitive processes, behaviors and products of human beings requires an understanding of the contexts they operate in and the tools and technologies available to them, and most-importantly, how those factors interact. Cognition does not occur in a vacuum, but rather is a complex product of the brain's capabilities and its environment.
Moving forward in the development of a science and practice requires more than descriptions of what we want to study and why. In many ways, we have been studying these phenomenon for decades. Cognitive engineering, naturalistic decision making, situated cognition, macrocognition…. we have wandered over a broad landscape making discoveries along the way, but as of yet it has been a rather random journey. The tools of progress forging a lasting paradigm remain the same for us as for others. According to Kuhn (1996), for any new paradigm to be lasting it must be capable of predicting different outcome than its predecessors to resolve observed anomalies, and in so doing must be able to extend those predictions to new areas for which no precedent exists. If we cannot, the paradigm fails and people return to previous paradigms.
Setting ourselves on a productive course, therefore, requires that as a field we develop sound research methodologies, tools and approaches. We must move beyond merely observing human behaviors and making theories about cognitive processes, a necessarily subjective process. It is necessary that methods be developed for evaluating and comparing competing hypotheses; for moving from descriptive theories to those that are predictive. Only then will this field form a lasting body of science that will be useful.
Just as cognition does not exist in a vacuum, neither does research; it's outcome and methods are largely dependant upon its goals. The ultimate aim of our profession is the better design of tools, technologies and organizations to support cognitive work. Achieving this goal necessitates that we tackle the really hard problems. Drawing predictive generalizations from observations of processes that are, by definition, affected by context is a daunting challenge, but a necessary one. Finding ways to measure and assess human cognition in order to validate and compare theories and hypotheses in new settings is equally challenging but necessary. The course we must take is difficult but clear. It remains for us to successfully meet that challenge.

Endsley, M. R. (2006). Chapter 36. Expertise and Situation Awareness. In A. Ericsson, N. Charness, R. Hoffman, & P. Feltovich (Eds.), Cambridge Handbook on Expertise and Expert Performance. Cambridge: Cambridge University Press.

Key Words:
ADA CTA

Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
In thinking about expertise, we often focus on skilled physical performance (e.g., the world-class tennis player or gymnast) or skilled decision making (e.g., the chess grandmaster). In addition to these aspects of performance, however, situation awareness (SA), an up-to-date understanding of the world around them, forms a critical cornerstone for expertise in most domains, from driving to aviation to military operations to medical practice. The characteristics that allow people to develop high levels of SA often develop silently alongside more observable features like skilled physical performance, even in tasks such as sports that are considered primarily physical in nature. Take for example the following excerpt from a magazine story about Wayne Gretzky, an all-time leading hockey scorer who set or tied 49 different National Hockey League records, including most goals, most points, and most assists.

Gretzky doesn't look like a hockey player. ... His shot is only average - or; nowadays, below average . .. Gretzky's gift, his genius even, is for seeing . .. To most fans, and sometimes even to the players on the ice, hockey frequently looks like chaos: sticks flailing, bodies falling, the puck ricocheting just out of reach. But amid the mayhem, Gretzky can discern the game's underlying pattern and flow, and anticipate what's going to happen faster and in more detail than anyone else in the building. Several times during a game you'll see him making what seem to be aimless circles on the other side of the rink from the traffic, and then, as if answering a signal, he'll dart ahead to a spot where, an instant later; the puck turns up. (McGrath, 1997)

Although undoubtedly Wayne Gretzky possessed the important physical skills associated with the sport of hockey, this article points out that the critical attribute that placed him head and shoulders above his contemporaries was mental - his ability to understand what was happening in the game and to anticipate where the puck would be. This superior situation awareness allowed him to be "ahead of the game" and outmatch bigger, faster, and better players. Similar stories can be found in other sports (for example, football, basketball, or tennis - see also Hodges et a1., Chapter 27) in which anticipating the actions of one's teammates, one's opponents, and where the ball is going are key to effective individual and team performance. The importance of situation awareness can be found even in a relatively straightforward sport such as golf, which at first glance might appear to be only a matter of a mechanical match between the golf swing and the distance and bearing to the hole. Even in this sport situation awareness has a role, however. Expert players will walk the course ahead of time to take in key situational features that make one course play differently from another. In the 2004 Masters Golf Tournament, Phil Mickelson won by sinking a putt on the last hole. Credited as critical to that putt was the fact that the player immediately previous to Mickelson putted from almost the exact same location. This allowed Phil Mickelson to "read" the hole - observing the winds and very slight variations of the grass and grades of the slope between the ball and the hole. He consciously worked to develop the best SA possible before taking his swing.
Situation awareness plays an even more important role in other domains, such as military operations, piloting, or air traffic control, where there are many factors to keep track of and these factors can change quickly and interact in complex ways. Effective decision making depends on high levels of SA, and thus so does effective performance. In this chapter I will discuss the ways in which SA is critical to expert performance and the factors that allow it to improve with the development of expertise in a domain. Studies from several different arenas will be presented to highlight the many difficulties that novices have in developing good SA and to show how SA improves as performers develop expertise.

Endsley, M. R. (2009). Chapter 20. Situation Awareness. In G. Salvendy (Ed.), Handbook of Human Factors and Ergonomics. London: John Wiley & Sons, Inc.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

An Annotated Bibliography of Studies and Reports Produced by the Advanced Decision Architectures Consortium of the Collaborative Technology Alliance from 2001 to 2010

Summary abstract:
As we move into the twenty-first century, the biggest challenge within most industries and the most likely cause of an accident receives the label of human error. This is a most misleading lerm, however, thaI has done much to sweep the real problems under the rug. It implies that people are merely careless or poorly trained or somehow not very reliable in general. In fact, in the vast majority of these incidents the human operator was striving against significant challenges. On a day-to-day basis, they cope with hugely demanding complex systems. They face both data overload and the challenge of working with a complex system. They are drilled with long lists of procedures and checklists designed to cope with some of these difficulties, but from time to time they are apt to fail. lndustry's typical response to such failures has been more procedures and more systems, but unfortunately, this only adds to the complexity of the system. In reality, the person is not the cause of these errors but is the final dumping ground for the inherent problems and difficulties in the technologies we have created. The operator is usually the one who must bring it all together and overcome whatever failures and inefficiencies exist in the system.

Endsley, M. R., Bolstad, C. A., Jones, D. G., & Riley, J. M. (2003). Situation Awareness Oriented Design: From User's Cognitive Requirements to Creating Effective Supporting Technologies. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society Conference. Denver, CO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Situation awareness is a fundamental construct driving human decision making in complex, dynamic environments. By creating designs that enhance an operator's awareness of what is happening in a given situation, decision making and performance can improve dramatically. The Situation Awareness-Oriented Design process provides a means to improve human decision-making and performance through optimizing situation awareness. This method has been used to develop and evaluate system design concepts in aviation, medical and information intelligence operations. It features three main components: SA Requirements Analysis, SA-Oriented Design Principles, and SA Measurement and Validation. This design process is user-centered, and derived from a detailed analysis of the goals, decisions and situation awareness requirements of the operator derived through a Cognitive Task Analysis methodology called Goal-Directed Task Analysis. The development of tool suites for supporting high levels of situation awareness in military command and control are presented to illustrate the use of the SAOriented Design process for translating the results of cognitive task analyses into to usercentered system designs.

Endsley, M. R., Bolte, B., & Jones, D. G. (2003). Designing for Situation Awareness: An Approach to Human Centered Design. London: Taylor & Francis.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book
PART ONE: UNDERSTANDING SITUATION AWARENESS IN SYSTEM DESIGN
1. User-centered Design
2. What is Situation Awareness?
3. SA Demons: The Enemies of Situation Awareness
4. The Design Process
PART TWO: CREATING SITUATION AWARENESS-ORIENTED DESIGNS
5. Determining SA Requirements
6. Principles of Designing for SA
7. Confidence and Uncertainty in SA and Decision Making
8. Dealing with Complexity
9. Alarms, Diagnosis, and SA
10. Automation and Situation Awareness
11. Designing to Support SA for Multiple and Distributed Operators

PART THREE: COMPLETING THE DESIGN CYCLE
12. Evaluating Design Concepts for SA
13. Applying SA-oriented Design to Complex Systems
Appendix A: Goal-directed Task Analysis for Commercial Airline Pilots

Summary abstract:
Preface
'Our Age of Anxiety is, in great part, the result of trying to do today 's jobs with yesterday's tools. . - Marshall McLuhan

While a clear understanding of one's situation is undoubtedly the critical trigger that allows the knowledge, skills, and creativity of the human mind to be successfully brought to bear in shaping our environment, very often people must work uphill, against systems and technologies that block rather than enhance their ability to ascertain the information they need. Knowledge in a vacuum is meaningless. Its use in overcoming human problems and achieving human goals requires the successful application of that knowledge in ways that are contextually appropriate. Yet, across a wide variety of engineered systems, people face an everwidening information gap-the gulf between the data that is available and the information that they really need to know.
This book addresses the information gap through system design. It presents a core set of principles and a methodology for engineers and designers who are seeking to nourish the situation awareness of their system's users. Operators of power plants, aircraft, automobiles, ships, command and control centers for military and large-scale commercial enterprises, intelligence operations, medical systems, and information management systems are all in need of technologies that allow people to effectively manage the information available to gain a high level of understanding of what is happening. They need systems designed to support situation awareness.
We are indebted to many people. First, we are grateful for the support and patience of our families during the writing of this book-may it lead to a better world for our children. We are thankful for the support of many of our colleagues, whose dedicated research has created the foundation upon which this book is based. Finally, we are indebted to the countless number of pilots, air traffic controllers, soldiers, and system operators who have volunteered their insights, experiences, time, and expertise in the hopes of bettering the tools of their profession. We also appreciate and acknowledge the support of our sponsors, the U.S. Army Research Laboratory Collaborative Technology Alliance and the NASA Langley Research Center, without whose assistance this book would not have been possible.

Although we are committed to scientific truth, there comes a point where this truth is not enough. where the application of truth to human objectives comes into play. Once we start to think in terms of utility, we must leave the placid environment of the laboratory, take off our white coats, and roll up our sleeves .... " Samuel Florman- 'The Civilized Engineer'

Endsley, M. R., & Jones, D. G. (2001). Disruptions, Interruptions and Information Attack: Impact on Situation Awareness and Decision Making. In In Proceedings of 45th Annual Meeting of the Human Factors and Ergonomics Society. Minneapolis, MN (pp. 63-67).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This paper presents a model of depicting the ways in which disruptions, interruptions and information attack can effect situation awareness and decision making in a variety of contexts. Those effected in military aviation include not just those in the cockpit, but also forward air controllers, ground based air traffic controllers and those in intelligence and support functions. The model incorporates the ways in which information attacks can effectively disrupt human decision making at various points in information processing. By carefully examining not just what cues might depict an attack to information systems, but also how human observers will be effected by such cues, more robust systems for protecting against disruptions and information attack can be developed.

Endsley, M. R., & Jones, D. G. (2001). Disruptions, Interruptions, and Information Attack: Impact on Situation Awareness and Decision Making. In In Proceedings of 45th Annual Meeting of the Human Factors and Ergonomics Society. Minneapolis, MN.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This paper presents a model of depicting the ways in which disruptions, interruptions and information attack can effect sittmtion awareness and decision making in a variety of contexts. Those effected in military aviation include not just those in the cockpit, but also forward air controllers, ground based air traffic controllers and those in intelligence and support functions. The model incorporates the ways in which information attacks can effectively disrupt human decision making at various points in information processing. By carefully examining not just what cues might depict an attack to information systems, but also how human observers will be effected by such cues, more robust systems for protecting against disruptions and information attack can be developed.

Endsley, M. R., Jones, D. G., Bolstad, C. A., & Riley, J. M. (2003). Designing to Support Situation Awareness in the Objective Force. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures

Summary abstract:
The SA-Oriented Design process provides a means to improve human decision-making and performance by optimizing situation awareness (SA) in system design. It provides a methodology and guidelines for overcoming the system complexity and data overload problems experienced in many systems and provides a means of supporting the needs of teams to have shared situation awareness to support their tasks. In this paper we will provide an overview of this process and show its application to the development of display tools to support SA in the Objective Force.

Ericsson, K. A., Charness, N., Feltovich, P. J., & Hoffman, R. R. (Eds.). (2006). Cambridge Handbook of Expertise and Expert Performance.: New York: Cambridge University Press.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book

Summary abstract:
This is the first handbook where the world's foremost "experts on expertise" review our scientific knowledge on expertise and expert performance and how experts may differ from non-experts in terms of their development, training, reasoning, knowledge, social support, and innate talent. Methods are described for the study of experts' knowledge and their performance of representative tasks from their domain of expertise. The development of expertise is also studied by retrospective interviews and the daily lives of experts are studied with diaries, In 15 major domains of expertise, the leading researchers summarize our knowledge of the structure and acquisition of expert skill and knowledge and discuss future prospects. General issues that cut across most domains are reviewed in chapters on various aspects of expertise, such as general and practical intelligence, differences in brain activity, self-regulated learning, deliberate practice, aging, knowledge management, and creativity.

Fan, X., McNeese, M., Sun, B., Hanratty, T., Laurel Allender, & Yen, J. (2006). Human-Agent Collaboration for Time Stressed Multi-Context Decision Making. In In Proceedings of Collaborative Technology Alliance (CTA) Advanced Decision Architectures (ADA) Sub Group, 2006. IEEE Transactions On Systems, Man, And Cybernetics, Part A: Systems And Humans, 2006 U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. http://agentlab.psu.edu/lab/publications/Fan_SMC2009.pdf.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; Human-Centered Computing, Cognitive Agents, Context Switching, Naturalistic Decision Making

Summary abstract:
Multi-context team decision making under time stress is an extremely challenging issue faced by various real world application domains. In this study we employ an experience-based cognitive agent architecture (R-CAST) to address the informational challenges associated with military command and control (C2) decision making teams, the performance of which can be significantly affected by dynamic context switching and tasking complexities. Using context switching frequency and task complexity as two factors, we conducted an experiment to evaluate whether the use of R-CAST agents as teammates and decision aids can benefit C2 decision making teams. Members from a US Army ROTC (Reserve Officer Training Corps) organization were randomly recruited as human participants. They were grouped into ten Human-Human teams each composed of two participants and ten Human-Agent teams each composed of one participant and two R-CAST agents as teammates and decision aids. Statistical inference of the experiment results indicates that R-CAST agents can significantly improve the performance of C2 teams in multi-context decision making under varying time-stressed situations.

Fan, X., Oh, S., McNeese, M., Yen, J., Cuevas, H., Strater, L., & Endsley, M. R. (2008). The Influence of Agent Reliability on Trust in Human-Agent Collaboration. In In Proceedings of European Conference on Cognitive Ergonomics (ECCE 2008), Madeira, Portugal.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings Reliability, Automation usage decisions, Trust, Agent

Summary abstract:
Motivation – To investigate ways to support humanautomation teams with real-world, imperfect automation where many system failures are the result of systematic failure.
Research approach – An experimental approach was used to investigate how variance in agent reliability may influence human's trust and subsequent reliance on agent's decision aids. Sixty command and control (C2) teams, each consisting of a human operator and two cognitive agents, were asked to detect and respond to battlefield threats in six ten-minute scenarios. At the end of each scenario, participants completed the SAGAT queries, followed by the NASA TLX queries.
Findings/Design – Results revealed that teams with experienced human operators accepted significantly less inappropriate recommendations from agents than teams with inexperienced operators. More importantly, the knowledge of agent's reliability and the ratio of unreliable tasks have significant effects on human's trust, as manifested in both team performance and human operators' rectification of inappropriate recommendations from agents.
Originality/Value – It represents an important step toward uncovering the nature of human trust in humanagent collaboration.
Take away message – This research has shown that given even minimal basis for understanding when the operator should and should not trust the agent recommendations allows operators to make better AUDs, to have better situation awareness on the critical issues associated with automation error, and to establish better trust in intelligent agents.

Fan, X., Sun, B., Sun, S., McNeese, M., & Yen, J. (2006). Rpd-Enabled Agents Teaming with Human for Multi-Context Decision Making. In In Proceedings of Fifth International Joint Conference on Aunomous Agents and Multi-Agent Systems (AAMAS 06), Hakodate, Japan.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Categories and Subject Descriptors
I.2.11 [Arti¯cial Intelligence]: Distributed Arti¯cial In-
telligence|Intelligent agents, Multiagent systems
General Terms
Design, Experimentation, Human Factors
Keywords
Cognitive agent, Human-centered teamwork, Naturalistic de-
cision making, Multiple contexts, Attention switching

Summary abstract:
Team decision making under stress involving multiple con- texts is an extremely challenging issue faced by various real world application domains. This research is targeted at cou- pling cognitive agent technology and human-centered team- work to address the informational challenges associated with Command and Control (C2) teams in contemporary military operations. Two sets of experiments, each with various set- tings of context switching frequencies and tasking complex- ities, were conducted. To ensure that the human subjects were familiar with the C2 context, they were selected from US Army ROTC (Reserve O±cer Training Corps) students. Experiments on C2 teams that involve human subjects only were conducted ¯rst. We observed the decision making be- havior of human subjects and incorporated expert behaviors into R-CAST|an agent architecture built upon a naturalis- tic decision making model that captures how domain experts make decisions based on experiences and situational similar- ity recognition. We then conducted another set of experi- ments with R-CAST agents as teammates and decision aids for human subjects. The results show that RPD-enabled agents can signi¯cantly improve the tasking capacity of C2 teams in multi-context decision making under stress. It also suggests that higher demand situations require more com- petent teammates.

Fan, X., Sun, S., McNeese, M., & Yen, J. (2005). Extending Recognition-Primed Decision Model for Human-Agent Collaboration. In In Proceedings of the Fourth International Joint Conference on Autonomous Agents and Multi Agent Systems (AAMAS'05), July 2005.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Categories and Subject Descriptors
I.2 [Arti¯cial Intelligence]: General|Cognitive simula-
tion; I.2.11 [Arti¯cial Intelligence]: Distributed Arti¯cial
Intelligence|Intelligent agents, Multiagent systems
General Terms
Design, Experimentation, Human Factors
Keywords
Human-centered teamwork, Human-agent collaboration, Nat-
uralistic decision making, Recognition re¯nement, Shared
situation awareness

Summary abstract:
There has been much research investigating team cogni- tion, naturalistic decision making, and collaborative tech- nology as it relates to real world, complex domains of prac- tice. However, there has been limited work in incorporat- ing naturalistic decision making models for supporting dis- tributed team decision making. The aim of this research is to support human decision making teams using cognitive agents empowered by a collaborative Recognition-Primed Decision model. In this paper, we ¯rst describe an RPD- enabled agent architecture (R-CAST), in which we have im- plemented an internal mechanism of decision-making adap- tation based on collaborative expectancy monitoring, and an information exchange mechanism driven by relevant cue analysis. We have evaluated R-CAST agents in a real-time simulation environment, feeding teams with frequent decision- making tasks under di®erent tempo situations. While the result conforms to psychological ¯ndings that human team members are extremely sensitive to their workload in high- tempo situations, it clearly indicates that human teams,

when supported by R-CAST agents, can perform better in the sense that they can maintain team performance at acceptable levels in high time pressure situations.

Fan, X., Sun, S., Sun, B., Airy, G., McNeese, M., Yen, J., Hanratty, T., & Dumer, J. (2005). Collaborative Rpd-Enabled Agents Assisting the Three-Block Challenge in Command and Control in Complex and Urban Terrain. In In Proceedings of Behavior Representation in Modeling and Simulation (BRIMS).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings Collaborative Agents, Recognition-Primed Decision Making, Human-Centered Teamwork, Contexts

Summary abstract:
One of the challenging issues in the domain of C2 in complex and urban terrain is how to assist human combat staff to effectively collaborate and make decisions under multiple contexts, and to help people switch their attentions to the most urgent decision tasks. This paper describes a comprehensive approach that uses RPD-enabled agents to support timely decision-making under multiple contexts. We introduce the R-CAST decision support system and report our effort of using the R-CAST agent architecture to assist human combat staff in dealing with information challenges in complex and urban terrain. The simulation demonstrates that by modeling the information requirements of the three block challenge as relevant cues and expectancies, R-CAST agents can effectively share relevant information for complex decision situations.

Fan, X., & Yen, J. (2006). R-Cast: Integrating Team Intelligence for Human-Centered Teamwork. In In Proceedings of the Twenty-Second AAAI Conference on Artificial Intelligence, July 22–26, 2007, Vancouver, British Columbia. Published by The AAAI Press, Menlo Park, California. Sponsored by the Collaborative Technology Alliance (CTA) Advanced Decision Architectures (ADA) Sub Group, 2006 U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate.
http://www.aaai.org/Papers/AAAI/2007/AAAI07-243.pdf.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures

Summary abstract:
Developing human-centered agent architectures requires the integral consideration of architectural flexibility, teamwork adaptability, and context reasoning capability. With the integration of various forms of team intelligence including shared teamwork process and progress, dynamic context management and information dependency reasoning, and recognition-primed collaborative decision mechanism, R-CAST offers a flexible solution to developing cognitive aids for the support of human-centered teamwork in information and knowledge intensive domains. In this paper, we present the key features of R-CAST. As evidence of its applications in complex real-world problems, we give two experimental evaluations of R-CAST as teammates and decision aids of human Command and Control teams.

Fan, X., & Yen, J. (2007). R-Cast: Integrating Team Intelligence for Human-Centered Teamwork. In In Proceedings of Twenty-Second AAAI Conference on Artificial Intelligence (AAAI-07).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Developing human-centered agent architectures requires the integral consideration of architectural flexibility, teamwork adaptability, and context reasoning capability. With the integration of various forms of team intelligence including shared teamwork process and progress, dynamic context management and information dependency reasoning, and recognition-primed collaborative decision mechanism, R-CAST offers a flexible solution to developing cognitive aids for the support of human-centered teamwork in information and knowledge intensive

domains. In this paper, we present the key features of R-CAST. As evidence of its applications in complex real-world problems, we give two experimental evaluations of R-CAST as teammates and decision aids of human Command and Control teams.

Fan, X., & Yen, J. (2007). Realistic Cognitive Load Modeling for Enhancing Shared Mental Models in Human-Agent Collaboration. In In Proceedings of Sixth International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS'07).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Categories and Subject Descriptors
I.2.11 [Artificial Intelligence]: Distributed Artificial Intelligence—
Intelligent agents, Multiagent systems
General Terms
Design, Experimentation, Human Factors
Keywords
Cognitive modeling, Human-centered teamwork, Shared belief
maps, Multi-party communication

Summary abstract:
Human team members often develop shared expectations to predict each other's needs and coordinate their behaviors. In this paper the concept "Shared Belief Map" is proposed as a basis for developing realistic shared expectations among a team of Human-Agent-Pairs (HAPs). The establishment of shared belief maps relies on inter-agent information sharing, the effectiveness of which highly depends on agents' processing loads and the instantaneous cognitive loads of their human partners. We investigate HMM-based cognitive load models to facilitate team members to "share the right information with the right party at the right time". The shared belief map concept and the cognitive/processing load models have been implemented in a cognitive agent architecture—SMMall. A series of experiments were conducted to evaluate the concept, the models, and their impacts on the evolving of shared mental models of HAP teams.

Feltovich, P. J., Hoffman, R. R., & Woods, D. D. (2004). Keeping It Too Simple: How the Reductive Tendency Affects Cognitive Engineering. IEEE Intelligent Systems, 90-95.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Certain features of tasks make them especially difficult for humans. These constitute leverage points for applying intelligent technologies, but there's a flip side. Designing complex cognitive systems is itself a tough task. Cognitive engineers face the same challenges in designing systems that users confront in working the tasks that the systems are intended to aid.

Feltovich, P. J., Bradshaw, J. M., Clancey, W. J., Johnson, M., & Bunch, L. (2008). Progress Appraisal as a Challenging Element of Coordination in Human and Machine Joint Activity. In In Proceedings of Eighth Annual International Workshop on Engineering Societies in the Agents World (ESAW 2007). Athens, Greece.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Coordination, culture, human-agent-robotic systems, joint activity, ontology, policy, predictability, regulation, teamwork, progress appraisal, common ground

Summary abstract:
Joint activity, as we define it, is a mutually interdependent endeavor that requires a degree of predictability among participating parties so that they can coordinate. Coordination, in turn, sometimes requires the parties to appraise the state of progress of their activities so that, if necessary, they can adjust their actions to meet coordination needs and communicate their status to others as appropriate. Increasingly, consequential work is being conducted by mixed groups of humans, software agents, and robots. A complaint about automation has been that it often does not have awareness of its own progress, and hence can give no warning before failure. In the current article, we address various issues associated with “progress appraisal” and the challenges it poses for human-machine systems. We point to some directions for possible solutions.

Feltovich, P. J., Bradshaw, J. M., Jeffers, R., Suri, N., & Uszok, A. (2004). Social Order and Adaptability in Animal and Human Cultures as Analogues for Agent Communities: Toward a Policy-Based Approach In In Proceedings of Fourth International Workshop on Engineering Societies in the Agents World. Imperial College, London.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In this paper we discuss some of the ways social order is maintained in animal and human realms, with the goal of enriching our thinking about mechanisms that might be employed in developing similar means of ordering communities of agents. We present examples from our current work in humanagent teamwork, and we speculate about some new directions this kind of research might take. Since communities also need to change over time to cope with changing circumstances, we also speculate on means that regulatory bodies can use to adapt.

Ferris, T., Hameed, S., Penfold, R., & Rao, N. (2007). Tactons in Multitask Environments: The Interaction of Processing Code and Modality. In In Proceedings of 51st Annual Meeting of the Human Factors and Ergonomics Society. Baltimore, MD.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Tactons, or vibrotactile icons, have been proposed as a means to communicate complex concepts to users and to support multitasking in environments involving numerous visual and/or auditory tasks and stimuli. This study investigated the role of processing code in the interpretation of tactons while performing concurrent visual tasks in such environments. Participants decoded tactons composed of spatiotemporal patterns of vibrations . requiring spatial processing . and interpreted one of two types of visual task stimuli . requiring either spatial or categorical processing . in a driving simulation. Compared to singletask performance, there was a significantly larger dual-task performance decrement when the tacton task was paired with the visual task requiring spatial (as compared to categorical) processing. The findings are consistent with the assertion of Multiple Resource Theory that interference between concurrent tasks is greater when these tasks involve the same processing code. They illustrate how distributing task-related information across modalities is beneficial but not sufficient to avoid task interference. A direct implication of the findings is to avoid the use of spatiotemporal tactons in environments which rely heavily on spatial processing resources, such as car cockpits or flight decks.

Ferris, T., Hameed, S., & Sarter, N. (2009). Tactile Displays for Multitask Environments: The Role of Concurrent Task Processing Code. In In Proceedings of World Haptics 2009 Conference. Salt Lake City, UT. BEST PAPER AWARD.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
KEYWORDS: Tacton Displays, Multiple Resource Theory, Driving

INDEX TERMS: H.1.2 [Models and Principles]: User/Machine Systems—Human Information Processing; H.5.2 [Information Interfaces and Presentation]: User Interfaces—Haptic I/O

Summary abstract:
The distribution of tasks and stimuli across multiple modalities has been proposed as a means to support multitasking in data-rich environments. In particular, the tactile channel and, more specifically, communication via the use of tactile/haptic icons have received considerable interest in recent years. Past research has examined primarily the impact of concurrent task modality on the effectiveness of tactile information presentation. In contrast, the present study investigates to what extent the interpretation of complex tactile patterns – "tactons" – is affected by another attribute of information: the processing code of concurrent tasks. Participants decoded tactons composed of temporal patterns of vibrations (categorical data) – and concurrently interpreted one of two types of visual task stimuli – requiring either spatial or categorical processing – in a driving simulation. Compared to single-task performance, both dual-task conditions showed a performance decrement. As predicted by Multiple Resource Theory, this decrement was significantly larger when the tacton task was paired with the visual task requiring categorical (as compared to spatial) processing. The findings from this study can serve as input to multidimensional quantitative models of timesharing performance. From an applied perspective, the results suggest that nonspatially-encoded tactons would be preferable in environments which rely heavily on spatial processing, such as car cockpits or flight decks.

Ferris, T., Penfold, R., Hameed, S., & Sarter, N. (2006). The Implications of Crossmodal Links in Attention for the Design of Multimodal Interfaces: A Driving Simulation Study In In Proceedings of 50th Annual Meeting of the Human Factors and Ergonomics Society. San Francisco CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The design of multimodal interfaces rarely takes into consideration recent data suggesting the existence of considerable crossmodal spatial and temporal links in attention. This can be partly explained by the fact that crossmodal links have been studied almost exclusively in spartan laboratory settings with simple cues and tasks. As a result, it is not clear whether they scale to more complex settings. To examine this question, participants in this experiment drove a simulated military vehicle and were periodically presented with lateralized visual indications marking locations of roadside mines and safe areas of travel. Valid and invalid auditory and tactile cues preceded these indications at varying stimulus-onset asynchronies. The findings confirm that the location and timing of crossmodal cue combinations affect response time and accuracy in complex domains as well. In particular, presentation of crossmodal cues at SOAs below 500ms and tactile cuing resulted in lower accuracy and longer response times.

Ferris, T. K., & Sarter, N. B. (2008). Crossmodal Links between Vision, Audition, and Touch in Complex Environments. Human Factors Journal. (February 2008).

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Objectives: This study sought to determine whether performance effects of crossmodal spatial links that were observed in earlier laboratory studies scale to more complex environments and need to be considered in multimodal interface design. It also revisits the unresolved issue of cross-modal cuing asymmetries.
Background: Previous laboratory studies employing simple cues, tasks, and/or targets have demonstrated that the efficiency of processing visual, auditory, and tactile stimuli is affected by the modality, lateralization, and timing of

surrounding cues. Very few studies have investigated these cross-modal constraints in the context of more complex environments to determine whether they scale and how complexity affects the nature of crossmodal cuing asymmetries.
Method: Amicroworld simulation of battlefield operations with a complex task set and meaningful visual, auditory, and tactile stimuli was used to investigate cuing effects for all cross-modal pairings.
Results: Significant asymmetric performance effects of cross-modal spatial links were observed. Auditory cues shortened response latencies for collocated visual targets but visual cues did not do the same for collocated auditory targets. Responses to contralateral (rather than ipsilateral) targets were faster for tactually cued auditory targets and each visual-tactile cuetarget combination, suggesting an inhibition-of-return effect.
Conclusions: The spatial relationships between multimodal cues and targets significantly affect target response times in complex environments. The performance effects of cross-modal links and the observed cross-modal cuing asymmetries need to be examined in more detail and considered in future interface design.
Application: The findings from this study have implications for the design of multimodal and adaptive interfaces and for supporting attention management in complex, data-rich domains.

Fiore, S. M., & Hoffman, R. R. (2003). Naturalistic Decision Making and the Practice of Science in National Security Research. In In Proceedings of 6th International Conference on Naturalistic Decision Making. Pensacola Beach, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Critical to meeting the needs arising from the government's evolving role in our nation's security is a broad understanding of how to guide, and even change, the interaction between science practice and science policy. From a practical standpoint, it is important that technologies be investigated for their potential applicability to national security. From a theoretical standpoint, the concepts that drive the investigation and development of new technologies and the refinement of emerging technologies must also be identified. Because of the tension that inherently arises from dichotomizing basic and applied research, we suggest that, via the appropriate blend of ecologically and epistemologically valid research, scientists can simultaneously address these needs.
In this poster we describe how Naturalistic Decision Making as a paradigm for research provides a useful model for science practice associated with the complex and dynamic areas impacting national security. First we elaborate on how NDM's reliance on both epistemological relevance and ecological salience (see Hoffman & Deffenbacher, 1993) articulates a model for NDM research as it relates to national security. Ecological salience describes the degree to which the materials or tasks of study pertain to what is actually perceived or done in an operational setting. Epistemological relevance describes the degree to which the experimental approach relies on concepts from extant theories. Via simultaneous utilization of these approaches, we may be able to better develop an understanding of the complexities of human performance in national security related tasks. Second, we discuss examples of how concepts derived from NDM can be used as operationally relevant starting points for research in national security. These range from understanding performance at the individual and cognitive level (e.g., expertise and perceptual processes) to the team and organizational level (e.g., shared mental models). For example, research in remote sensing imagery (e.g., Hoffman, Markman, & Carnahan, 2001) and pattern recognition processes by experienced aviators (e.g., Fiore, Jentsch, Oser, & Cannon-Bowers, 2000) are both directly relevant to a number of national security areas (e.g., pattern recognition by security screeners). In sum, we will show how the practice of science as it relates to research in national security relevant areas can usefully apply the methods and theories derived from naturalistic decision making.

Fisher, A., McDermott, P. L., & Fagan, S. (2009). Bandwidth Allocation in a Military Teleoperation Task. In In Proceedings of Human-Robot Interaction Conference, San Diego, CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Categories and Subject Descriptors
H.5.2 Information Interfaces and Presentation, User Interfaces –

Interaction styles
General Terms
Human Factors, Performance, Design, Experimentation
Keywords
Human-robot interaction, resolution, frame rate, teleoperation, color, grayscale

Summary abstract:
The implications of bandwidth allocation are described for teleoperation in a military task that involved navigation, target detection, and target identification. Color versus grayscale imagery was manipulated. Participants themselves traded off resolution and frame rate settings. Participants minimized switching between resolution/frame rate settings and tended to use settings with high resolution/low frame rate. Courses completed with the highest resolution (and lowest frame rate) had the fastest target identification times, but no other differences were observed between settings. Color imagery offered advantages for overall course time and the time to identify a tank as friendly or enemy.

Flach, J. M., & Hoffman, R. R. (2003). The Limitations of Limitations. IEEE Intelligent Systems, 18(1), 94-96.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
One of the principles of human-centered computing, the Aretha Franklin principle, states, Do not devalue the human in order to justify the machine. Do not criticize the machine in order to rationalize the human. Advocate the human–machine system in order to amplify both. The implication we pursue in this article has to do with the notion of human limitations. In the introduction to his text on engineering psychology, Christopher Wickens wrote, “One major purpose of this book is to examine human capabilities and limitations in the specific area of information processing. The second purpose is to demonstrate how knowledge of these limitations can be applied in the design of complex systems with which humans interact.”2 The first sentence in this quotation clearly recognizes that humans have capabilities. However, the second sentence seems to imply that it is the limitations that are most relevant in the design of complex systems. In a similar vein, Barry Kantowitz and Robert Sorkin wrote, “Indeed, many human factors analysts believe that minimizing human error is the primary goal of any human factors design. If people never made errors, there would be little need for a science of human factors” (italics added).3 Such statements, and there are scads of them in the literature, portray the human as the weaker link in any complex system. And the design focus tends to be on protecting the system from the limitations and errors that are associated with that weak link. In this essay, we argue that human factors and applied cognitive psychologists have not just been selective in regarding certain human characteristics as limitations, but also have selected the wrong things and for the wrong reasons.

Foltz, P. W. (2002). Chapter 13. Quantitative Cognitive Models of Text and Discourse Processing. In A. Graesser, M. Gernsbacher, & S. Goldman (Eds.), The Handbook of Discourse Processes. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:

For the field of discourse processing to advance. researchers must understand the underlying cognitive processes involved. The creation of models of discourse processing permit researchers to develop predictions based on their understanding of these cognitive processes. For these models to be testable. they must be implemented in a way that they can generate specific quantitative predictions that can be compared against research data. Current quantitative models have proved to be successful in accomplishing these goals. Researchers can run simulations of human discourse processing and test the effectiveness of the models. This permits an improved understanding of how humans process discourse. as well as the development of practical applications that simulate human processing.

Foltz, P. W. (2003). Book Chapter: Content Processing with Latent Semantic Analysis: Essays, Teams and Clinical Interviews. In L. Lagerwerf, W. Spooren, & L. Degand (Eds.), Determination of Information and Tenor in Texts: Multidisciplinary Approaches to Discourse. Münster, Germany: Nodus Publikationen.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Latent Semantic Analysis (LSA) is a computational model of human knowledge acquisition and a practical application for information retrieval and concept-based text matching. This paper illustrates w~ys in which LSA can be applied to performing content analyses of text and discourse. Three example domains are shown: The analysis of student essays for judging knowledge, the analysis ofteam discourse for predicting team performance and automatic tagging of discourse content, and the analysis of clinical interviews of patients with schizophrenia for predicting the presence and severity of the disease. The results' show that overall, LSA can be used in these domains for modeling cognitive and social properties as well as providing useful applications that make predictions based on automated discourse analysis.

Foltz, P. W., Laham, D., & Derr, M. (2003). Automated Speech Recognition for Modeling Team Performance. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society Conference. Denver, CO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
While team tasks provide a wealth of data on individual and team performance, techniques for modeling team communication can be quite effortful and time-consuming. Automated techniques of analyzing team discourse provide the promise of quickly judging team performance and permitting feedback to teams both in training and in operations. In previous research, techniques using Latent Semantic Analysis (LSA) have proven successful for analyzing team transcripts. However, converting the audio discourse into transcripts often requires hand transcription. In this work, we describe applying automated speech recognition (ASR) to team transcripts and using the output of the ASR to predict overall team performance. Results indicate that ASR can be used in conjunction with semantic methods of modeling team communication to provide accurate predictions of performance. The work has potential for assisting operators in the performance of their tasks because it can “listen”’ and in real-time evaluate fieform verbal communication from a variety of sources.

Foltz, P. W., & Lee, A. Y. (2004). Chapter 9. Adaptive Learning Systems: Toward More Intelligent Analyses of Student Responses. In V. Oostendorp, Breure, & Dillon (Eds.), Creation, Use, and Deployment of Digital Information: NMSU.

Key Words:
ADA CTA
Advanced Decision Architectures

Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
A critical issue for using information systems is the need for assessing what people have learned and for using that information to provide substantive additional instruction. The creation of electronic training material is relatively easy; however, creating systems that truly adapt to an individual student is more difficult. For example, textbooks can be scanned to create electronic textbooks for students to read, but these electronic textbooks may be no better than the paper version if they do not assess what the student knows or present only material the student needs.

Foltz, P. W., Lee, A. Y., Bond, G., & Martin, M. (2009). Chapter 22. Models, Methods, and Tools for the Adaptability of Teams. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section IV. Communicating Information across the Team: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
SSTR (Stability, Security, Transition and Reconstruction) missions often require that diverse, distributed experts from multinational forces, non-governmental organizations, and other government agencies work together. Commanders and teams trained as Warfighters often must acquire different skills to perform effectively for STIR operations. While some knowledge can transferfrom warfighting skills, other skills may be needed, such as the ability to perform effective decision-making in novel cultural situations and developing multi-functional teams from coalition forces. This raises a number of issues about how to effectively assess and measure performance in such operations and how tools can be developed that provide appropriate support during SSTR operations.
The domain of SSTR operations provides a rich area for examining cognitive, social, and cultural aspects of collaboration while also providing information that should be generalizable to military team performance over a wide number of different domains. For example, commanders and team members must understand how cultural and social differences influence behaviors such as information sharing and managing uncertainty or risk. However, collaborative technology that merely supports information exchange will be necessary, but not sufficient to insure collaboration among highly diverse team members solving complex problems. The overall objective of the present work is to develop and validate models, methods, and automated tools for measurement of performance in teams performing Stability, Security, Transition, and Reconstruction (SSTR) operations.
The work described in this chapter focuses on methods to assess and enhance collaboration in teams and the effects of culture and social issues (e.g., trust) on team performance. Learning and transfer of the teams' skills was examined by having teams perform in an SSTR task environment where they were either collocated with other team members or separated and only able to communicate through collaborative systems. Finally, automated methods were developed to predict team performance through analysis of the communication among the team members. We first describe some ofthe issues associated with the areas of learning and transfer, trust in teams, and automated communication analysis. Then we provide an overview of experiments performed to examine these issues.

Foltz, P. W., Martin, M. J., Cooke, N. J., Kiekel, P. A., & Gorman, J. (2003). Automated Team Communication Analysis with Latent Semantic Analysis. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making

Summary abstract:
While team tasks provide a wealth of data on individual and team performance, techniques for modeling team tasks can be quite effortful and time-consuming. Automated techniques of team modeling provide the promise of quickly judging team performance and permitting feedback to teams both in training and in operations. One of the most complex aspects of modeling team performance is modeling team member's dialogues. We describe the use of Latent Semantic Analysis (LSA) for automatically analyzing and coding team discourse. LSA is a fully automatic corpus-based statistical method for extracting and nferring relations of expected contextual usage of words in discourse. In this research, we describe two approaches to analyzing team discourse. The first approach measures the semantic content of the team dialogue as a whole and accurately predicts the team's performance on a simulated military mission. The second approach categorizes the contents of each statement made by team members using an established set of tags. These tagged statements can then be used to predict team performance. Performance on tagging was only 15% below the performance of trained human annotators. Future improvements, and implications for the design of automated systems for measuring team communications are discussed.

French, J., Ghirardelli, T. G., Swoboda, J., Ho, S., Nguyen, H., Tokarcik, L., Walrath, J., & Winkler, R. (2003). Modes of Control of an Unmanned Ground Vehicle (UGV). In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making

Summary abstract:
Unmanned Ground Vehicles (UGVs) are envisioned for a variety of functions that can provide increased situation awareness (SA) and understanding to commanders as well as to the Objective Force Warrior. The objective of this study was to measure the effects of different modes of control (joystick, voice, joystick and voice in combination, and simulated autonomous control) of a UGV on operator performance. We also examined simulated degradation of video signal strength. Participants were 22 soldiers recruited from the 16th Ordnance Battalion at Aberdeen Proving Ground, MD. Each was randomly assigned to one of the four control modes between-group conditions and experienced all four levels of the video quality conditions. We found differences in navigation performance and workload measures.

Galie, J., Ho, H.-N., & Jones, L. A. (2009). Influence of Contact Conditions on Thermal Responses of the Hand. In In Proceedings of Third Joint Eurohaptics Conference and Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems Salt Lake City, UT, USA, March 18-20, 2009 (pp. 587-592).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
CR Categories: G.3 [Mathematics of Computing]: Probability
and Statistics – Experimental Design; H1.2 [Model and
Principles]: User/Machine System; H.5.2 [Information Interfaces
and Presentation]: User Interfaces – Theory and methods; Usercentered
design
Keywords: temperature, thermal display, perception

Summary abstract:
A series of experiments was conducted to evaluate how contact pressure and surface roughness influence the heat flux conducted out of the skin or object during contact. Changes in skin temperature assist in identifying objects held in the hand. In the first experiment an infrared thermal imaging system was used to measure skin temperature and contact area as participants generated forces ranging from 0.1 to 6 N with their index finger. The results showed that skin temperature decreased by an average of 5.5 oC across the range of forces studied and that the changes were greatest between 0.25-0.35 N and from 4-6 N. The second and third experiments examined the effect of the surface roughness of an object on skin temperature and on the perceived coldness of the object. A set of six copper blocks was machined to create a range of surface profiles. There was a slight decrease in skin temperature as the surface

roughness of the object increased, contrary to theoretical predictions. Although small, these changes were perceptible as participants consistently chose the rougher of two stimuli when asked to select the cooler stimulus. These results indicate that contact pressure and surface roughness influence the change in skin temperature during contact and that they can have a perceptible influence on the perceived properties of objects held in the hand. Thermal models need to account for these effects if realistic feedback is to be presented in a thermal display.

Gillan, D. J. (2008). Human-Robot Interaction.II: The Impact of Human Factors on Unmanned Systems. In In Proceedings of 52nd Annual Meeting of the Human Factors and Ergonomics Society. 22-26 September 2008. New York City, NY USA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The sophistication of robotics systems has increased the utility of unmanned systems for complex military operations. The increasing capability and functionality of current and future robotics requires comparable enhancements to robotics interfaces and displays for tasking and controlling unmanned systems. The symposium participants identified key issues and challenges in human-robot interaction with respect to situation awareness (SA), perception and performance, and workload. The purpose of the symposium is to discuss current research findings and how these findings can be applied. The authors and audience will discuss the challenges of conducting human-robot interaction (HRI) research and the lessons learned for the design of human-robotic interactions and interfaces.

Gillan, D. J., & Gillan, C. T. (2006). Effects of Motion on the Perception of Static Features in a Display. In In Proceedings of 50th Annual Meeting of the Human Factors and Ergonomics Society. San Francisco CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Displays that use motion typically contain both dynamic and static features. We hypothesized that, relative to a no motion condition, representational momentum (the forward displacement of the representation of a moving object) might influence the perception of static distance between two objects when the objects had just moved away from each other or just moved toward each other. Two experiments tested the hypothesis by manipulating the end distances between two moving dots and the type of motion (Motion Away, Motion Towards, No Motion). In Experiment 1, the distance that the dots moved was the same for all six end distances, whereas in Experiment 2, the distance moved was proportional to the end distance. Participants estimated the distance at the end of the motion on every trial. The results of both experiments showed that the Motion Away produced greater estimates of distance than the other conditions. This effect was most pronounced at the longest end distances in Experiment 2. The results suggest designers should be cautious in using motion in displays for tasks that involve estimates of static distance.

Gillan, D. J., Riley, J., & McDermott, P. (2010). Chapter 4. The Cognitive Psychology of Human-Robot Interaction. In M. Barnes and F. Jentsch (Eds.), Human-Robot Interactions in Future Military Operations: Ashgate Publishing, Inc.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section
COGNITION AND HRI

Summary abstract:

Technology extends human capabilities. For much of human history, technological development focused on enhancing physical abilities -- for example, hammers increase our strength; transportation technologies extend our ability to move (Gillan & Schvaneveldt, 1999). In contrast, many technological innovations since the mid-20th Century have focused on enhancing human cognitive abilities – for example, computing technologies extend our ability to process, store, and represent symbolic information (Gillan & Schvaneveldt, 1999).
When the Czech playwright, Karel Capek, first coined the term robot (from the Slav, robota, meaning work or forced labor) in his 1921 play, Rossum's Universal Robots, he foresaw technological development that would extend the ability to perform virtually any task (Capek, 1921/2004). Interestingly, he foresaw the use of robots to perform both physical and intellectual tasks since the Czech word, rozum, means "mind" or "intellect". The robots that Capek described were human-like androids capable of supplanting humans. In the play, the robots seem to value physical work in that they spare the life of one human, based on their observation that he works with his hands.
As in Capek's vision of robots, modern robots' capabilities span a wide variety of tasks. We constrain this chapter by focusing on a set of robotic tasks related to military contexts. The goal of this chapter is to examine selected cognitive processes that operators of robotic systems will need to apply as they control, supervise, and/or monitor robots performing these tasks. Consequently, we have also restricted our analysis of cognitive processes to those most closely associated with an operator's activities while a robot performs one of these tasks.

Gillan, D. J., & Sapp, M. V. (2005). Static Representation of Object Motion. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Displaying motion information is useful in dynamic tasks, such as tracking or predicting the course of moving objects or systems (e.g., unmanned ground or air vehicles, troops, or weather). Static representations of object motion may be useful when technological limitations prevent use of dynamic displays. The present experiment examined people's interpretations of a variety of static cues to represent object motion. Participants viewed and rated two static types of representation of object motion -- motion lines and arrows. The features of object motion that participants rated were distance traveled, direction, path, speed, and acceleration. The results show that observers reliably interpret certain static cues to represent features of object motion, especially distance, direction, path and speed; the cues examined were not interpreted as representing acceleration. The results are interpreted as guidelines for design of displays that include object motion information.

Gonzalez, C. (2002). The Role of Cognitive Modeling in Enhancing Dynamic Decisions. In In Proceedings of 24th Annual Meeting of the Cognitive Science Society. Fairfax, VA. (pp. 1005).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Dynamic Decision Making is characterized by multiple and interdependent decisions, autonomous environments, and real-time evaluation and action (Brehmer, 1990). There seems to be increasing agreement on. how we make decisions in this type of situations. Decision makers in dynamic environments recognize typical' situations and typical responses and use their knowledge to adapt their strategies "on the fly" (payne, Bettman, and Johnson, 1993; Klein, 1998).

Gonzalez, C. (2003). ACT-R Implementation of an Instance-Based Decision Making Theory. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

An Annotated Bibliography of Studies and Reports Produced by the Advanced Decision Architectures Consortium of the Collaborative Technology Alliance from 2001 to 2010

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making

Summary abstract:
The Instance-Based Learning Theory (IBLT) proposes that in dynamic decision-making (DDM) decision makers achieve control over a system through recognition, accumulation and refinement of decision-making instances. Each instance contains information on a situation, an action, and a utility of a decision. IBLT is a general theory that explains how people make decisions in dynamic environments and CogIBLT is the implementation of such theory in a cognitive architecture, ACT-R. This paper introduces IBLT, describes its implementation in ACT-R, its predictions, and discusses the implications of this work to Objective Force.

Gonzalez, C., Lerch, J. F., & Lebiere, C. (2003). Instance-Based Learning in Dynamic Decision Making. Cognitive Science, 27(4), 591-635.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Dynamic decision making; Instance-based learning; Cognitive modeling; Decision making;
Water purification plant

Summary abstract:
This paper presents a learning theory pertinent to dynamic decision making (DDM) called instancebased learning theory (IBLT). IBLT proposes five learning mechanisms in the context of a decision-making process: instance-based knowledge, recognition-based retrieval, adaptive strategies, necessity-based choice, and feedback updates. IBLT suggests in DDM people learn with the accumulation and refinement of instances, containing the decision-making situation, action, and utility of decisions. As decision makers interact with a dynamic task, they recognize a situation according to its similarity to past instances, adapt their judgment strategies from heuristic-based to instance-based, and refine the accumulated knowledge according to feedback on the result of their actions. The IBLT's learning mechanisms have been implemented in an ACT-R cognitive model. Through a series of experiments, this paper shows how the IBLT's learning mechanisms closely approximate the relative trend magnitude and performance of human data. Although the cognitive model is bounded within the context of a dynamic task, the IBLT is a general theory of decision making applicable to other dynamic environments.

Gonzalez, C. (2003). Verbal Protocols in Real-Time Dynamic Decision-Making In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society Conference. Denver, CO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This study presents the results from the analyses of verbal protocols elicited from inexperienced and experienced participants of a real-time, Dynamic Decision-Making (DDM) task. This research intends to complement a series of studies performed in DDM environments analyzing the cognitive structures and processes involved in learning in DDM. Results show that inexperienced and experienced participants differ in several ways: in the way they distribute attention to different parts of the system, in their awareness of the relationship of the attributes involved in the decision making process, and in their coordination to make decisions in real time. These results have been used to support the refinement of a cognitive model developed to explain how people learn in DDM tasks.

Gonzalez, C. (2004). The Relationships between Cognitive Ability and Performance in Dynamic Decision Making. Intelligence Journal, 33(2).

An Annotated Bibliography of Studies and Reports Produced by the Advanced Decision Architectures Consortium of the Collaborative Technology Alliance from 2001 to 2010

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Cognitive ability; Dynamic decision making; Practice-Centered Design.

Summary abstract:
This study investigated the relationships between cognitive ability (as assessed by the Raven Progressive Matrices Test [RPM] and the Visual-Span Test [VSPAN]) and individuals' performance in three dynamic decision making (DDM) tasks (i.e., regular Water Purification Plant [WPP], Team WPP, and Firechief). Participants interacted repeatedly with one of the three microworlds. Our results indicate a positive association between VSPAN and RPM scores and between each of those measures and performance in the three dynamic tasks. Practice had no effect on the correlation between RPM score and performance in any of the microworlds, but it led to an increased correlation between VSPAN score and performance in Team WPP. The pattern of associations between performance in microworlds and assessments of cognitive ability was consistent with the task requirements of the microworlds. These findings provide insight into the cognitive demands of dynamic decision making and the dynamics of the relationships between cognitive ability and performance with task practice.

Gonzalez, C. (2005). Decision Support for Real-Time Dynamic Decision Making Tasks. Organizational Behavior and Human Decision Processes Journal, 96, 142-154.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Dynamic decision making; Cognitive support; Feedback; Feedforward; Cognitive feedback

Summary abstract:
By definition, dynamic decision making dictates that multiple and interrelated decisions be made in a continuously changing environment. Such decision making is difficult and often taxes individuals' cognitive resources. Here I investigated ways in which to support decision making in these environments. I evaluated three forms of decision support: outcome feedback, cognitive feedback, and feedforward that incorporated (to varying degrees) common features of learning theories associated with dynamic tasks. Participants in a laboratory experiment performed a real-time, dynamic decision-making task while receiving one of the diVerent types of decision support. During the Wrst 2 days, individuals received one type of decision support, but on the third day they performed the task without this support. Participants who received feedforward improved their performance considerably and continued to exhibit improved performance even after discontinuation of the decision support on the third day. Neither outcome feedback nor cognitive feedback resulted in improved performance. More research is necessary to conclusively identify the best forms of dynamic decisionmaking support and their durability when transferred to new tasks.

Gonzalez, C. (2005). Learning to Make Decisions in Dynamic Enrivonments: Effects of Time Constraints and Cognitive Abilities. Human Factors, 46(3), 449-460.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
This study investigated the effects of time constraints and cognitive abilities on dynamic decision making (DDM). The learning and performance of individuals trained in a DDM task with time constraints were compared with those

who were trained without time constraints. Although all participants received the same total amount of time to perform the task, individuals under more stringent time constraints were given 3 times more practice trials on the first 2 days of the study than were people under less stringent time constraints. Despite the additional practice runs, participants under high time constraints performed worse than did participants under low time constraints on the 3rd day of the study. A subsequent analysis of cognitive abilities and decision heuristics revealed that individuals' actions corresponded with simple heuristic predictions more closely with minimal practice than with extended practice, under high rather than low time constraints, and in individuals with low rather than high cognitive abilities. These findings suggest that mere repetition of a task with less time within a trial is counterproductive to learning and that learning depends on cognitive abilities. Potential applications of this research include the design of training procedures for dynamic tasks.

Gonzalez, C. (2005). Task Workload and Cognitive Abilities in Dynamic Decision Making. Human Factors, 47(1), 92-101.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Researchers often treat workload as a task-dependent variable. To evaluate the effect of workload on individuals' performance, researchers commonly use several methods, such as varying the complexity or number of tasks that test participants are asked to handle or placing individuals under time constraints. Only rarely have researchers investigated workload as a variable dependent on individuals' cognitive abilities. This study investigated workload during dynamic decision making in terms of its dependence on both task workload and cognitive abilities. The findings demonstrate detrimental effects of both high task workload and low cognitive abilities. Further, the results show that high workload is more detrimental in individuals with low cognitive abilities than in individuals with high cognitive abilities. Potential applications of this research include the design of new workload studies and new training protocols in which psychometric tests are used.

Gonzalez, C., & Golenbock, J. (2003). Impact of Numerical and Graphical Formats on Dynamic Decision Making Performance: An Eye-Tracking Study. In In Proceedings of First Latin American Conference of Human-Computer Interaction. Rio de Janeiro, Brazil.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Eye-tracking, attention, graphical and numerical interface

Summary abstract:
This paper presents a study in which we manipulated the interface of a computer simulation into: graphical and numerical formats. We obtained both performance and eye-tracking learning curves from individuals assigned to one of these two conditions. Our findings indicate that although performance is not different between the two interfaces, the amount of attention as measured by the number of eye-tracking points was very different in the graphical and numerical conditions. Attention increased over time in the numerical condition, but was stable in the graphical condition. These results showed that the strategies used to make decisions in dynamic environments vary according to the form of information presentation.

Gonzalez, C., Juarez, O., & Giloni, J. (2002). Modeling Coordination in Team Dynamic Resource Allocation. In In Proceedings of Sixth Annual ACT-R Workshop. Carnegie Mellon University. Pittsburgh, PA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Dynamic Decision Making (DDM)
-Multiple and interdependent decisions
-Continuously changing independent environment (exogenous events)
-Decisions made in real-time
Coordination in Team DDM
-Coordination
="Managing dependencies between activities" Malone and Crowston (1994)
= "Joint efforts of independent actors towards mutually defined goals" [NSF, 1989]
- Coordination in Team DDM
= Allocation of tasks and sharing information should occur at the right time and accurately
- How is coordination developed in a team dynamic task?

Gonzalez, C., Martin, M., & Hansberger, J. T. (2006). Feedforward Effects on Predictions in a Dynamic Battle Scenario. In In Proceedings of 50th Annual Meeting of the Human Factors and Ergonomics Society. San Francisco CA. (pp. 265-269).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Commanders face many challenges in their efforts to control the battlefield. Friction (i.e., sources of delay) in the commander's control system, coupled with the dynamics of the battlefield, requires commanders to act before threatening battlefield events occur. Effective control of the battlefield thus requires accurate predictions. This paper describes the results of a preliminary study concerned with the effect of FeedForward (FF) on the accuracy of predictions in dynamic battle situations. FF, given in the form of expert advice prior to simulated battle, did not reliably improve predictions. Exploratory analyses, however, indicate that FF guided attention to a subset of the task variables important for accurate prediction. Furthermore, FF produced quicker and more decisive victories than practice alone. In conjunction with the positive performance trend for the FF group, these findings indicate that FF facilitates strategy development and may lead to higher levels of Dynamic Decision Making (DDM) performance over time.

Gonzalez, C., & Quesada, J. (2004). Learning in Dynamic Decision Making: The Recognition Process. Computational & Mathematical Organization Theory, 9(4), 287-304.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
cognitive representation, dynamic decision making, recognition

Summary abstract:
The apparent difficulty that humans experience when asked to manage dynamic complexity might be related to their inability to discriminate among familiar classes of objects (i.e., flawed recognition). In this study we examined the change in individuals' recognition ability, as measured by the change in the similarity of decisions they made when confronted repeatedly with consistent dynamic situations of varying degrees of similarity. The study generated two primary findings. First, decisions became increasingly similar with task practice, a result that suggests gradually improving discrimination by the participants. Second, the similarity was determined by the interaction of many task features rather than individual task features. The general principles highlighted by this study are applicable to dynamic situations. For example, with practice, decision makers should be able to learn to identify the time at which to intervene to achieve the maximal effect during dynamic decision making.

Gonzalez, C., Saner, L., Endsley, M., Bolstad, C. A., & Cuevas, H. M. (2009). Chapter 14. Modeling and Measuring Situation Awareness in Individuals and Teams. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section III. Acting on Battlefield Information: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
Situation Awareness (SA) is a complex construct that cannot be fully understood from a single perspective. Rather, SA entails a multifaceted process in which individual and team factors, at both the micro and macro levels, need to be integrated. For example, research on team SA needs to take into account the factors that contribute to a given person's individual SA while integrating the factors that contribute to any two team members' shared SA, as well as team or organizational SA. Also, the complexity of SA arises from mUltiple individual cognitive abilities including learning, working memory, different levels of perception, understanding, projection, etc. These individual factors interact with multiple team and organizational factors such as geographical distribution, collaborative tool usage, network proximity, similarity of the individuals' background experiences, and familiarity with each others' skills, among others.
In this chapter we bring together different levels and factors of SA complexity into an integrated framework. Throughout the duration of the Army Research Laboratories Advanced Decisions Architectures (ARLADA) research program, we have addressed the complexity of SA by advancing the development arid validity of measures at the individual and team levels. We have also created computational models of SA that have moved forward the descriptive nature of SA into more concrete and formal representations. This chapter summarizes all the past work we have done within this program and attempts to integrate all the previous findings into a research framework. The details of each of these research pieces can be found in the previous original publications. The integrated framework presented here came from a combination of scientific research methods at the micro and macro levels that included computational models, and laboratory and field studies. The framework integrates our past findings from experimental laboratory studies and ACT-R cognitive computational models on individual SA to field experiments and social network analysis of team and shared SA.

Gonzalez, C., Vanyukov, P., & Martin, M. K. (2005). The Use of Microworlds to Study Dynamic Decision Making. Computers in Human Behavior, 21(2), 273-286.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Dynamic decision making; Microworlds; Synthetic task environments; Cognitive demands

Summary abstract:
Dynamic decision-making (DDM) research grew out of a perceived need for understanding how people control dynamic, complex, real-world systems. DDM has describable characteristics and, with some unavoidable sacrifice of realism, is suitable for study in a laboratory setting through the use of complex computer simulations commonly called ‘microworlds’. This paper presents a taxonomic definition of DDM, an updated review of existing microworlds and their characteristics, and a set of cognitive demands imposed by DDM tasks. Although the study of DDM has garnered little attention to date, we believe that both technological advancement and the relationships between DDM and naturalistic decision making, complex problem solving, and general systems theory have made DDM a viable process by which to study how people make decisions in dynamic, real-world environments.

Gonzalez, C., & Wimisberg, J. (2007). Situation Awareness in Dynamic Decision-Making: Effects of Practice and Cognitive Abilities. Journal of Cognitive Engineering and Decision Making, 1(1), 56-74.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
The goal of this research is (a) to investigate the effects of task practice on situation awareness (SA); (b) to investigate how cognitive ability – in particular, working memory – moderates this practice effect on SA; and (c) to investigate effects of the SA measurement procedure (covering or uncovering the display while queries are answered). Task practice and working memory influence SA. However, the dynamics of the relationship between working memory and SA over time are not well understood, particularly with regard to using different SA measures. This research reports an experiment in which different SA measurement methods were used while participants played a computer simulation over several days. SA was measured using two query methods: a covered method in which questions were asked while the display was blanked out, and an uncovered method in which questions were asked while the display was shown. A working memory measure was collected from participants. Results indicate that the relationship between working memory and SA diminishes with task practice and differs between a covered and uncovered method. We also found that SA improvement with practice depends on the way in which SA is measured. We discuss the implications of these findings for understanding SA development, SA measurement, and the relationship of working memory in this process. The results from this study have clear implications for systems design, for the design of learning aids, and for SA measurement.

Gonzalez, C., & Wimisberg, J. K. (2003). Can I Learn to Be Aware? Learning Situation Awareness in Dynamic Environments. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making

Summary abstract:
This paper presents an experiment to assess ability to learn Situation Awareness (SA) in a Dynamic Decision Making task. Participants used a simulation of a task called: Water Production Plant (WPP) and the SAGAT methodology to assess SA over 18 trials of running the WPP simulation. Results show that, although participants learn to perform better in the task they do not improve their SA over time. Also, overall SA scores and performance were not correlated. Learning showed significant only in some of the SAGAT questions but not over aggregated data per SA level. The SA overall score in level 3 is significantly different from the other levels. When controlling for individual differences in fluid intelligence, the results show SA learning. After analyzing this learning effect over the three SA levels, the results showed that only SA Level 3 accounts for the learning.

Gorman, J. C., Foltz, P. W., Kiekel, P. A., Martin, M. J., & Cooke, N. J. (2003). Evaluation of Latent Semantic Analysis-Based Measures of Communications Content. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society Conference. Denver, CO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:

Team process is thought to mediate team member inputs and team performance. Among the team behaviors identified as process variables, team communications have been widely studied. We view team communications as a team behavior and also as team information processing, or team cognition. Within the context of a Predator Uninhabited Air Vehicle (UAV) synthetic task, we have developed several methods of communications content assessment based on Latent Semantic Analysis (LSA). These methods include: Communications Density (CD) which is the average task relevance of a team's communications, Lag Coherence (LC) which measures taskrelevant topic shifting over UAV missions, and Automatic Tagging (AT) which categorizes team communications. Each method is described in detail. CD and LC are related to UAV team performance. AT-human is comparable to human-human agreement on content coding. The results are promising for the assessment of teams based on LSA applied to communication content.

Graham, J., Gonzalez, C., & Doyle, M. (2003). Using Communication Patterns in the Design of an Adaptive Organizational Structure for Command and Control. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society Conference. Denver, CO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
What type of analysis should be used to inform design when both the future organizational structure and the experimental simulation are tenuous? Neither the application of a qualitative process tracing method nor low-level quantitative organizational designs are warranted. We hypothesized the analyses of high-level communication patterns in a role-playing exercise of a future organization structure would yield results that could both inform organizational design and shape iterative experimental designs. This study summarizes the comparison between communication patterns in an envisioned organizational structure and the actual patterns of information exchange of experienced military participants role-playing staff members in a future organizational design. The comparison between the hypothesized and actual communication performance indicated a different distribution of communication interaction from the expected. These results help guide both the future organizational concept as well as next iteration experiments.

Graham, J., Schneider, M., Bauer, A., Bessiere, K., & Gonzalez, C. (2004). Shared Mental Models in Military Command and Control Organizations: Effect of Social Network Distance. In In Proceedings of 48th Annual Meeting of the Human Factors and Ergonomics Society. New Orleans, LA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This paper presents an investigation on the relationship between social network distances and shared mental models in military command and control organizations. Previous research has shown that physical distance is the gold standard for high performance (Olson & Olson, 2000). However, social network distance may be equally or more important, as social network graphs inherently take into account the group's context and environment (Krackhart, 1994). We conducted this research on a new 56-member command and control organization using computer-based collaborative tools as they engaged in a five day simulation exercise. As military command and control organizations are difficult to evaluate based on outcome and performance, we chose shared mental models as a proxy. We hypothesized that in a command and control organization, social network distance and physical distance are independent of one another. Further we hypothesized that social network distance would be a predictor of mental model congruence. We found that there is a very weak positive correlation between social network distance and physical distance. Further, we found that, controlling for physical distance, social network distance is a predictor of mental model congruence. This research validates that high frequency of communication, mediated by computer based collaborative tools, can effectively generate shared mental models.

Graham, J., Zheng, L., & Gonzalez, C. (2006). A Cognitive Approach to Game Usability and Design: Mental Model Development in Novice Real-Time Strategy Gamers. Cyber Psychology & Behavior, 9(3), 361-366.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
We developed a technique to observe and characterize a novice real-time-strategy (RTS) player's mental model as it shifts with experience. We then tested this technique using an offthe- shelf RTS game, EA Games Generals. Norman defined mental models as, "an internal representation of a target system that provides predictive and explanatory power to the operator." In the case of RTS games, the operator is the player and the target system is expressed by the relationships within the game. We studied five novice participants in laboratorycontrolled conditions playing a RTS game. They played Command and Conquer Generals for 2 h per day over the course of 5 days. A mental model analysis was generated using player dissimilarity-ratings of the game's artificial intelligence (AI) agents analyzed using multidimensional scaling (MDS) statistical methods. We hypothesized that novices would begin with an impoverished model based on the visible physical characteristics of the game system. As they gained experience and insight, their mental models would shift and accommodate the functional characteristics of the AI agents. We found that all five of the novice participants began with the predicted physical-based mental model. However, while their models did qualitatively shift with experience, they did not necessarily change to the predicted functional- based model. This research presents an opportunity for the design of games that are guided by shifts in a player's mental model as opposed to the typical progression through successive performance levels.

Green, C. C., Griffin, D. E., Blascovich, J. J., Bradshaw, J. M., Bunce, S. C., Gannon, J., Gazzaniga, M., Loftus, E., Moore, G. J., Moreno, J., Rasure, J. R., Rintoul, M., Schwade, N. D., Smith, R. L., Walch, K. S., & Young, A. M. (2008). Emerging Cognitive Neuroscience and Related Technologies. Report of the Committee on Military and Intelligence Methodology for Emergent Neurophysiological and Cognitive/Neural Science Research in the Next Two Decades Standing Committee for Technology Insight—Gauge, Evaluate, and Review Division on Engineering and Physical Sciences Board on Behavioral, Cognitive, and Sensory Sciences Division on Behavioral and Social Sciences and Education . National Research Council. Washington, DC: The National Academies Press.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
The intelligence community (IC) faces voluminous amounts of scientific information produced and available on a global scale. To improve analysis of the information, the Technology Warning Division (TWD) of the Defense Intelligence Agency's (DIA's) Defense Warning Office (DWO) asked the National Research Council (NRC), in 2004, to establish the Committee on Defense Intelligence Agency Technology Forecasts and Reviews. That committee authored the report Avoiding Surprise in an Era of Global Technology Advances. Avoiding Surprise provided the IC with a technology warning methodology not previously available to it and led the DIA to request that the NRC establish a standing committee to continue to provide related assistance. In May 2005, the Standing Committee for Technology Insight—Gauge, Evaluate, and Review (TIGER) was established to assist the DWO of DIA in formulating future studies to be completed by NRC ad hoc committees. This report of the ad hoc Committee on Military and Intelligence Methodology for Emergent Neurophysiological and Cognitive/Neural Science Research in the Next Two Decades is the third report to be produced under the purview of the TIGER Standing Committee.

Grossman, J., Voshell, M., Tinapple, D., Tittle, J., & Woods, D. D. (2003). Perceiving Affordances through a Robot's Sensors. In In Proceedings of 6th International Conference on Naturalistic Decision Making. Pensacola Beach, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The role of perception in cognition has been a basic theme in NDM work; this work looks at how to enhance the perception of the affordances of scenes for remote observers working through a robotic platform. One of the obstacles is seeing affordances through a robot's sensors As robotic system developers strive to achieve a certain level of autonomy, they underestimate the need for coordination with human stakeholders. This has been generalized as:
(Robin) Murphy's Law: any deployment of robotic systems will fall short of the target level of autonomy, creating or exacerbating a shortfall in mechanisms for coordination with human problem holders. (Murphy et al., 2002)
Roboticists don't start with the demands of the settings they claim to assist. When you start with the field you see different things about how robots and people need to work together. By beginning with the demands of complex operational contexts such as search and rescue and first response to chemical/biological incidents, we find alternative models for the relationship of people and robots. Many technological advances can be viewed as means for perception at a distance or action at distance. New capabilities for robotic systems are a major step forward within this tradition of coupling people to scenes at a distance. In this view robotic capabilities represent new powers for human problem and stake holders to project intent at a distance.
To achieve intent at a distance in remote explorations of an environment, a robotic platform provides an action/perception stand in at a distance for its handler. This de-couples the natural dynamic relationship between properties of the scene being explored and the human perceptual system of the remote handler (e.g., Cutting, 1986; Warren, in press). The decoupling undermines the remote observers perception of affordances in the scene (Gibson, 1979) which is illustrated by recent cases of HRC where remote observers experience various difficulties in understanding the environment being traversed by a robotic platform (Casper, 2002; Darken, Kempster, and Peterson, 2001). The perceptual ambiguities (scale, rate of motion, keyhole effect, gaze coordination) make clear that seeing though a remote camera is not the equivalent performance as having a human observer at a scene, as perception is an active process in which the observer causes the visual image to change by performing actions in the environment
While a great deal of work has addressed creating an illusion of presence for remote observers, this work has not addressed the fundamental ambiguities that arise in remote perception or how to enable the perception of affordances when access to a scene is mediated. Our research demonstrates several initial techniques to enhance raw sensor feeds to recover what was lost by decoupling the human perceptual processor from the environment being explored.

Grossman, J. B., Woods, D. D., & Patterson, E. S. (2007). Supporting the Cognitive Work of Information Analysis and Synthesis: A Study of the Military Intelligence Domain. In In Proceedings of 51st Annual Meeting of the Human Factors and Ergonomics Society. Baltimore, MD.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Information Analysis and Synthesis (henceforth "IAS") is a type of cognitive work that plays a key role in many high-performance, complex, and mission-critical domains. These can range from tactical military intelligence to scientific or technological forecasting, business and financial intelligence to national strategic counterterrorism, and include areas as disparate as geopolitical policy analysis to computer network intrusion detection. The specific subject of this study is the military intelligence domain as one instantiation of IAS. Several innovative ethnographic and cognitive task analysis methods were used to observe team-based distributed work done by actual domain practitioners. The main investigative effort took the form of a scaled-world study, leveraging a real world tactical intelligence training exercise as a natural laboratory for investigating the contrasts between weaker and stronger

IAS. Specifically, we examined the role of instructors in providing broadening checks to the team analytic process, and mapped the findings to an existing framework.

Gunawan, L. T., Voshell, M., Oomes, A. H. J., & Woods, D. (2007). Envisioning Collaboration at a Distance for the Evacuation of Walking Wounded. In In Proceedings of 4th International ISCRAM Conference (B. Van de Walle, P. Burghardt and C. Nieuwenhuis, eds.), Delft, the Netherlands.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings Collaboration, coordination, disaster response, evacuation, design for coordination, walking wounded

Summary abstract:
The "walking wounded" is a category of disaster victims that can help themselves in finding their way to safety. The problem we address here is how first responders, walking wounded, and other rescue personnel can coordinate their joint activities more efficiently in order to accomplish the evacuation as quickly as possible. We focus our design on the "coordination loops" in the disaster response organization, both vertically across levels of authority, and horizontally among responders in the same echelon. In our envisioned scenario of a chemical accident we identify the most important interactions through which activities are coordinated that are crucial for a successful evacuation. We propose three different “coordination devices” that can be used by the walking wounded, the rescuers in the fields, and the people in the command center. We believe our approach, explicitly designing support systems for coordination first, will lead to important improvements in the daily practice of disaster response.

Hancock, J. P., McGinnis, S., & Hillis, D. (2003). Fast Constraint Satisfaction Engine for Co-Evolutionary Approach to Tactical Plan Analysis. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making

Summary abstract:
From the original Federated Laboratories program, through the present Advanced Decision Architectures CTA, ARL has been researching the application of Genetic Algorithms (GAs) to planning applications. The current research involves the exploration of applying Co-Evolutionto analyze multi-sided, non-linear military operations. The extension of planning research to multi-sided operations has extended the requirements on plan assessment beyond those of standard wargames.
This paper details the design of the Constraint Satisfaction based Wargame Operation Processor (WOPR). WOPR is the faster-than-real-time operation plan assessor that is designed to support ARL co-evolution planning research. WOPR is composed of two fundamental parts, the Constraint Solver and the Wargame Processor. The Vargame Processor takes one output of the Genetic Algorithm, (one plan per faction), and plays out the scenario as a discrete event wargame, using the Constraint Satisfaction system to flesh-out the detailed event parameters. The Wargame Processor walks through the steps of the faction's plans in event times pace, selecting the appropriate constraints to apply. Factional Plan elements, andforce statuses are passed to the Constraint Solver to process in context. All status details are maintained to facilitate review by human planners and scoring by the machine. The scoring system is highly reconfigurable to support the experimentation needs of ARL.
Also discussed is the design of the Constraint Satisfaction Integrated Development Environment (CSIDE). CSIDE is a tool that was rapidly created to support the research development of an integrated set of Constraint Sets (CS). The system supports visual representation of Constraint Set elements: Variables, Generators, and Constraints, as well as their various interconnections. When the user has authored a Constraint Set, CSIDE allows the user to setup XMLfiles of test inputs, and to run them against the CS under development. CSIDE is useful in the original development of Constraint Sets and their extensional development and testing.

Hancock, P. A., & Diaz, D. D. (2002). Ergonomics as a Foundation for a Science of Purpose. Theoretical Issues in Ergonomic Science, 3(2), 115-123.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Ergonomics; Science of purpose; Human performance.

Summary abstract:
The argument here is at once simple and profound. The first premise is that technology is the most powerful 'shaping' force on the planet today. The second premise is that individual impact on this force is most evident at the humanmachine interface. A corollary of the second premise is that unity in intention is to be found in the aggregate of individual actions. Ergonomics, as the pursuit that mediates between operator and technology, is, therefore, the first step along the path to a science of intention as expressed in 'world' changes. Some initial observations on the integration of existing behavioural theories represent the first step along this royal road.

Hancock, P. A., & Szalma, J. L. (2003). The Future of Neuroergonomics. Theoretical Issues in Ergonomic Science, 4(1-2), 238-249.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Brain and behaviour; ergonomics; ethics; human factors; intentionality; neuroscience.

Summary abstract:
This paper addresses the theoretical, the philosophical, and the ethical considerations associated with the advent and future of neuroergonomics. These issues will demand increasing attention as knowledge of the linkage of brain function to technology-based action improves from its current coarse-grained level to a more fine-grained understanding. These developments promise to open extraordinary opportunities for improved human–machine and human–human interaction, and represent the next major step in human–machine evolution. The social and psychological implications of these changes, however, must be considered if abuse of this conception is to be circumvented.

Hancock, P. A., Weaver, J. L., & Parasuraman, R. (2002). Sans Subjectivity, Ergonomics Is Engineering. Ergonomics, 45(14), 991 - 994.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
We much admire and agree with many of the points and issues that Annett has raised and believe his work has great value for both researchers and practitioners in ergonomics and allied ®elds. We also believe that Annett's paper will join others in giving the lie to the frequent assertion that ergonomics is an atheoretical ®eld, an `appliance science' (Hancock 1997), not ®t for the high company of theoretical psychology and at best a poor cousin to higher forms of engineering. Annett's rich theoretical observations, in contrast, begin to bring to the fore crucial philosophical questions that underpin the ergonomics enterprise.

Somewhat ironically, Annett highlights the central role of theory in ergonomics by discussing the use of subjective measures, which have often been criticized as being fundamentally fawed and unscientific, indeed even by some of the founders of the discipline, as Annett points out. We strongly agree with Annett's main points that all empirical observations have a subjective component, and that subjective methods, when developed and applied appropriately in accordance with accepted scienti®c criteria, have an important place in ergonomics. We raise two additional issues, however, where we believe Annett has not gone far enough and as commentators we solicit his further insight into these matters.

Harrison, C. L., & Gillan, D. J. (2005). The Role of Motion in Object Recognition. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Do motion cues influence object recognition when contour information is available? Three experiments examined four motion conditions for a variety of objects (no motion, random motion, atypical motion, and typical motion) when contour information was also available. A typical motion pattern was one that would normally be associated with the moving object, whereas atypical motion involved a regular motion pattern that was typical for one object in the set of 15 used in the experiments, but wasn't associated with the object in motion. In Experiments 1 and 2, the objects were made difficult to recognize, by eliminating vertices and by using small representations, respectively. In Experiment 3, large, complete contour wire frame pictures were used. In all experiments, recognition speed and accuracy were best for the typical motion condition and second best for the atypical motion. With easily-recognized objects, random motion led to faster recognition than no motion, whereas, with difficult recognition, random motion led to slower response times than no motion. The results are interpreted with a three-process model. Applications to the design of computer icons, signage, and camouflage are discussed.

Hillis, D., Barnes, M., Suantak, L., Schlabach, J., Chandrasekaran, B., Josephson, J. R., & Carroll, M. (2003). Collaborative Visualization Tools for Courses of Action (Coa) in Antiterrorist Operations: Combining Coevolution and Pareto Optimization. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making

Summary abstract:
This paper describes a combination of coevolution, specialized simulation, Pareto optimization, and interactive visualization to aid the investigation of the system dynamics in Stability and Support Operations (SASO) situations and to assist in the choice of favorable courses of action (COA). This system, which is partially completed, will consist of four parts: a coevolution engine, a wargamer specialized for SASO operations, a Pareto filter and graphical COA comparison tool, and a COA scenario visualization tool. Once the coevolution engine produces and selects COAs based on the scores provided by the wargamer, the Pareto filter excludes distinctly suboptimal friendly COAs. The narrowed set of favorable COAs is returned to the coevolution engine to generate more COAs, or is passed to the COA comparison tool so that human analysts can investigate the determinants of favorable outcomes, understand the tradeoffs, and further narrow the selection, possibly to a single COA, chosen for further investigation. The COA scenario visualization tool enables analysts to watch and meter the events of individual scenarios, facilitating analysis and understanding. This paper discusses the functions of each of the components, and how they can function together to support a commander's analysis and decision-making of a given scenario.

Ho, C.-Y., Nikolic, M. I., Waters, M. J., & Sarter, N. B. (2004). Not Now: Supporting Interruption Management by Indicating the Modality and Urgency of Pending Tasks. Human Factors, 43(3), 399-409.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Operators in complex event-driven domains must coordinate competing attentional demands in the form of multiple tasks and interactions. This study examined the extent to which this requirement can be supported more effectively through informative interruption cueing (in this case, partial information about the nature of pending tasks). The 48 participants performed a visually demanding air traffic control (ATC) task. They were randomly assigned to 1 of 3 experimental groups that differed in the availability of information (not available, available upon request, available automatically) about the urgency and modality of pending interruption tasks. Within-subject variables included ATC-related workload and the modality, frequency, and priority of interruption tasks. The results show that advance knowledge about the nature of pending tasks led participants to delay visual interruption tasks the longest, which allowed them to avoid intramodal interference and scanning costs associated with performing these tasks concurrently with ATC tasks. The 3 experimental groups did not differ significantly in terms of their interruption task performance; however, the group that automatically received task-related information showed better ATC performance, thus experiencing a net performance gain. Actual or potential applications of this research include the design of interfaces in support of attention and interruption management in a wide range of event-driven environments.

Ho, C.-Y., & Sarter, N. B. (2004). Supporting Synchronous Distributed Communication and Coordination through Multimodal Information Exchange. In In Proceedings of 48th Annual Meeting of the Human Factors and Ergonomics Society. New Orleans, LA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Increasingly, operators in complex event-driven domains, such as the military, need to coordinate their goals and activities with numerous co-located and distributed human and machine agents. One promising way to support this requirement is the introduction of multimodal interfaces that afford functions such as increased bandwidth, complementarity, redundancy, and substitution. To inform the design of a robust multimodal system, the present study explored natural tendencies for, and the role of context in, modality usage in the context of simulated battlefield operations. Three groups of three ROTC cadets/officers each completed a set of 30-minute scenarios. The within-subject variables included participant location, the availability of radio communication, the amount of coordination required by the scenario, and the tempo of operations. Our findings show that participants were highly selective in their use of multiple modalities. Multimodal interaction was observed primarily in the context of spatial tasks and for the purpose of supporting grounding, complementarity, and disambiguation. Joint modality usage patterns evolved over time within groups and varied as a function of factors such as scenario and interface management demands. The findings from this study provide important guidance for the design of multimodal combined HCI and CSCW interfaces and show that multimodal information exchange is a highly effective means of coordination.

Ho, H., & Jones, L. A. (2004). Material Identification Using Real and Simulated Thermal Cues. In In Proceedings of 26th Annual International Conference of the IEEE Engineering in Medicine and Biology Meeting, pp. 2462-2465.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Material identification, semi-infinite body
model, thermal display, thermal sensation

Summary abstract:

The objective of this study was to develop a thermal display for simulating the thermal cues associated with making contact with materials with different thermal properties. The thermal display was designed based on a semi-infinite body model. The performance of subjects using this display was compared to that with real materials in a material identification experiment. The results indicated that there was no significant difference in material identification when subjects were presented with real or simulated materials. The decreases in skin temperature were also comparable in the two experiments and were related to the contact coefficient of the material palpated, which is consistent with the semi-infinite body model. These findings suggest that thermal feedback in a haptic display can facilitate object recognition when visual cues are limited.

Ho, H.-N., & Jones, L. A. (2007). Development and Evaluation of a Thermal Display for Material Identification and Discrimination. ACM Transactions on Applied Perception, 4(2- Article 13).

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Categories and Subject Descriptors: G.3 [Mathematics of Computing]: Probability and Statistics—Experimental design; H.1.2
[Model and Principles]: User/Machine System; H.5.2 [Information Interfaces and Presentation]: User Interfaces—Evaluation/
methodology, haptic I/O, theory and methods, user-centered design; J.2 [Computer Applications]: Engineering
General Terms: Design, Experimentation, Human factors, Measurement, Performance, Theory
Additional Key Words and Phrases: Haptic interface, material identification, semi-infinite body model, thermal display, thermal
feedback, thermal perception, hand–object interaction, virtual environment

Summary abstract:
The objective of this study was to develop and evaluate a thermal display that assists in object identification in virtual environments by simulating the thermal cues associated with making contact with materials with different thermal properties. The thermal display was developed based on a semi-infinite body model. Three experiments were conducted to evaluate the performance of the display. The first experiment compared the ability of subjects' to identify various materials, which were presented physically or simulated with the thermal display. The second experiment examined the capacity of subjects to discriminate between a real and simulated material based on thermal cues. In the third experiment, the changes in skin temperature that occurred when making contact with real and simulated materials were measured to evaluate how these compare to theoretical predictions. The results indicated that there was no significant difference in material identification and discrimination when subjects were presented with real or simulated materials. The changes in skin temperature were comparable for real and simulated materials and were related to the contact coefficient of the material palpated, consistent with the semi-infinite body model. These findings suggest that a thermal display is capable of facilitating object recognition when visual cues are limited.

Ho, H.-N., & Jones, L. A. (2007). Monitoring Skin Temperature During Hand-Object Interactions. In In Proceedings of InfraMation Conference 2007 (pp. 1-8).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
An IR thermal measurement system was created to monitor skin temperature during hand-object interactions. The layout and optical arrangement of the system allowed for the measurement of skin temperature across the fingerpad during contact, together with contact force and contact area. An IR model was developed to compensate for the effects of the optical components that were placed between the fingerpad and IR camera. Based on this model, the measured thermal energy could be converted into a temperature distribution on the fingerpad during contact. The

performance of this system was evaluated with calibration tests and the results indicated that this system was capable of providing accurate temperature measurements without the limitations imposed by conventional thermal sensors. Measurements obtained with this system can be used to evaluate the validity of models used to predict the changes in skin temperature during hand-object interactions.

Ho, H.-N., & Jones, L. A. (2008). Modeling the Thermal Responses of the Skin Surface During Hand-Object Interactions. Journal of Biomechanical Engineering. ASME, 130, 21005-1 - 21005-8.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
The objective of this research is to analyze and model the decreases in skin temperature when the hand makes contact with an object at room temperature so that thermal feedback can be incorporated into haptic displays. A thermal model is proposed that predicts the thermal responses of the skin and object suiface as well as the heat flux exchanged during hand-object interactions. The model was evaluated by comparing the theoretical predictions of temperature changes to those experimentally measured using an infrared thermal measurement system. The thermal measurement system was designed to overcome the limitations imposed by contact thermal sensors, and was able to measure skin temperature during contact, together with the contact area and contact force. The experimental results indicated that over the pressure range of 0.73-10.98 kPa, changes in skin temperature were well localized to the contact area and were affected by contact pressure. The pressure in turn influenced both thermal contact resistance and blood flow. Over the range of contact forces typically used in manual exploration, blood perfusion and metabolic heat generation do not appear to have a significant effect on the skin s thermal responses. The theoretical predictions and the measured data were consistent in characterizing the time course and amplitude of the skin temperature change during contact with differences typically being less than 1 0 C between the two for pressures greater than 4 kPa. These findings indicate that the proposed thermal model is able to characterize and predict the skin temperature responses during hand-object interactions and could be used in a thermal display that simulates the properties of different materials.

Hoffman, R. R., & Hayes, P. J. (2004). The Pleasure Principle. IEEE: Intelligent Systems, 86-89.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
The list of "concepts that psychology really can't do without" includes such notions as neuronal connectionism, degrees of consciousness, mental representation of information, and dissociation. Of the pantheon of contributors to the history of psychology,Aristotle outranks all others in terms of the number of critical concepts he introduced, including the notion of the association of ideas, the law of frequency and the affiliated concept of memory strength, the notion of stage theories of development, the idea of distinguishing types of mental processes or faculties, the idea of scales of nature and comparisons between humans and animals, and last but not least, the Pleasure Principle.

Hoffman, R. R. (2007). Expertise out of Context: Papers from the Sixth International Conference on Naturalistic Decision Making. Mahwah, NJ: Lawrence Erlbaum Associates, Inc. (in production).

Key Words:
ADA CTA

An Annotated Bibliography of Studies and Reports Produced by the Advanced Decision Architectures Consortium of the Collaborative Technology Alliance from 2001 to 2010

Advanced Decision Architectures
Collaborative Technology Alliance
Book

Summary abstract:
The main theme of this volume is captured in its title. The authors were encouraged to discuss topics in Naturalistic Decision making (NDM), expertise studies, and cognitive systems engineering, with an eye toward questions of what happens when domain practitioners are forced, for one reason or another, to work outside of their comfort zone.

Hoffman, R. R. (2008). Human Factors Contributions to Knowledge Elicitation. Human Factors (50th Anniversary Special Issue), 50, 481-488.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Objective: The objective of this article is to lay out contributions of human factors to knowledge elicitation (KE) methodology.
Background: The background is historical, dating to about 1985, and involves the convergence of expert systems with applied psychology and cognitive psychology.
Method: The method is a literature review, focusing on past issues of Human Factors.
Results: Human factors researchers have contributed significantly to KE methodology. However, KE methodology "belongs to" a number of communities of practice and has applications that transcend individual disciplines.
Conclusion: Knowledge elicitation, thought of as a kind of cognitive task analysis, grows in importance with the increasing use of information technology to form complex sociotechnical work systems and the increasing importance of expertise to knowledge-based organizations.
Application: I discuss some open issues for further research and methodological investigation.

Hoffman, R. R. (2009). Cognitive Task Analysis for Creating Macrocognitive Work Systems. In Invited Presentation at the Annual Conference of the International Technology Alliance, sponsored by the Army Resarch Laboratory and The Ministry of Defense (Unted Kingdom). University of Maryland Conference Center, College Park, MD, September 2009.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This talk will describe Cognitive Task Analysis (CTA) methods that have been proven useful in the design of sociotechnical systems. A number of methods will be described, including the Critical Decision Method, the Cognitive Modeling Procedure, Workplace Observation, and Concept Mapping. The discussion will highlight strengths and weaknesses of methods, and appropriate combinations of methods. Applications of CTA will also be described in this presentation, converging on specific ITA needs and issues that require the empirical study of cognition in context. The ITA faces an "envisioned world problem" requiring choices and combinations of CTA methods appropriate for the investigation of the challenge questions.

Hoffman, R. R., Amin, R., Brents, C., Bunch, L., Carff, R., Endsley, M., Hancock, P. A., Klein, G., Moon, B., Marx, M., McDermott, P., & Woods, D. (2009). Theories and Methods for Measurement and Metrics for Advanced Decision Architectures Prepared as a deliverable to the ARL Advanced Decision Architectures Collaborative Alliance Cooperative Agreement DAAD19-01-2-0009. Prepared by University of West Florida/Institute for Human

and Machine Cognition,with contributions by Alion Science MAAD Operation Klein Associates Division of ARA Ohio State University Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Report
Chapter 1: About this ARLADA Task
Chapter 2: Basics of Measurement and Metrics
Chapter 3: Human Performance Measurement
Chapter 4: Hedonic Measurement
Chapter 5: Range Statistics and Learnability
Chapter 6: Modeling Range Statistics
Chapter 7: Range Statistics and Universal Metrics
Chapter 8: Measurement and Cognitive Task Analysis
Chapter 9: Macrocognitive Measurement
Chapter 10: Measurement at the "System Level"

Summary abstract:
This report expresses the findings from an ARLADA Task on developing measures and metrics that can be broadly applied in the analysis of any "advanced decision architecture." That is, the evaluation of intelligent technologies and decision aides and the cognitive work that is shaped by the software tools the architecture provides. This ARLADA Task effort had a broad goal of establishing foundations for measurement, especially measurement for cognitive work in sociotechnical work systems. Chapters cover the basics of measurement and measurement theory, human performance measurement, experimental methodology in the formation of measures and metrics, measures to evaluate cognitive work and measures to evaluate performance at the "system level." While presenting foundational ideas, the report also presents new ideas and mathematical treatments, intended to significantly extend measurement and metrics beyond traditions into new realms. In particular, this Report describes a new field of "Range Statistics," which presents general measures for assessing the learnability of softwaresupported work of any kind, and a means for measuring the resilience of cognitive work. These are new measures that can be taken all the way to "Universal Metrics" for the evaluation of the quality of cognitive work of any kind. The spirit of this ARLADA Task effort is captured by the quotation attributed to former Secretary of Defense Robert MacNamara: "We need to stop making what is measurable important and start making what is important measurable." Cognitive systems engineering seeks understanding of very high orders of cognitive activity and work complexity, matched by very high levels of importance to society. The view that guided this ARLADA Task was that the measurement of cognitive work must be taken to entirely new levels, ones that can address, for example, concerns such as team cognitive work (and not just one person-one machine interaction), and address the important trade-offs in cognitive work that emerge only when we consider action at the system level—which is, after all, where the final pay-off for any investment is realized.

Hoffman, R. R., Bradshaw, J. M., Hayes, P. J., & Ford, K. M. (2003). The Borg Hypothesis. IEEE Intelligent Systems, (September/October). pp. 73-75.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
What if intelligent computing were centered inside humans? This essay’s title is inspired by the nemesis of Jean-Luc Picard, captain of the starship Enterprise in the television series Star Trek: The Next Generation. The Borg are—or should we say “is”—a species consisting of organic beings symbiotically merged with technology. Each individual Borg is laden with all manner of appliances, ranging from laser eyeballs to appendages resembling drill presses to computational and communication devices implanted in their nervous systems. The Borg is a collective, meaning that they—or it— possess a single mind. That Borg mind has the single intent of “assimilating” all organic species

into the collective. Assimilation involves first injecting nanoprobes that thoroughly transform the organic being down to the molecular level, then grafting on the various appliances (or else growing them de novo like so many cloned carrots in a hydroponic garden). Wending their way through the galaxy in huge Rubik Cube-like vehicles, the Borg assimilate entire planets at a time and carve up starships as if they were roast beef, making them (it) an especially nasty adversary.
In our real world, we already routinely replace hip joints with titanium and inner-ear structures with microcircuits; we can carry telephones comfortably on our heads, and Web-enabled eyeglasses can augment our view of reality. To counter the effects of drowsiness or inattention, DaimlerChrysler is developing prototypes that continuously monitor drivers' physical and mental states, while DARPA's Augmented Cognition Program is planning an even more ambitious reach to "plug in" the warfighter of the future (www.darpa.mil/ipto/programs/augcog/index.htm). Portending an even braver and newer world, it's now possible to insert wires into a person's nerves to control appliances. We can even send such signals over the Internet, where they are decoded by computer and then fed into another person's nervous system.Human bodies are getting more and more plugged in. It's not easy to set aside questions of ethics and choice. It is not even possible. However, in this essay we simply overlook them in order to work toward our hypothesis. To do that, we must take you on a trip into space. Our argument is that if humanity decides to continue human exploration of space, we will sooner or later—probably sooner—be forced to center some intelligent computing inside humans.

Hoffman, R. R., & Deal, S. V. (2008). Influencing Versus Informing Design, Part 1: A Gap Analysis. IEEE: Intelligent Systems. Human Centered Computing, 72-75.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
In this and the next essay in this department, we reflect on the mismatch that can occur between the promise of intelligent technology and the results of technological interventions. Cognitive task analysis (CTA) has been offered as a way of revealing actual work, especially macrocognition, but the system development process can fail to bridge the gap between the products of CTA and the needs of software engineers. This is the first of two essays about bridging this gap. In this essay we discuss a success story of cognitive systems engineering to illustrate a product from CTA that speaks in a language that's similar to that of software designers. The second essay is about bridging the gap going from the other direction, providing designers with a CTA method that they themselves can use to ramp up their understanding of end users' true work needs.

Hoffman, R. R., & Elm, W. C. (2006). Human-Centered Computing (Hcc) Implications for the Procurement Process. IEEE: Intelligent Systems, pp. . 21(1), 74-81.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Most system designers and human factors engineers have participated in projects that culminated in systems that were highly constrained by short-term cost considerations. In the procurement of information processing and intelligent technology for complex sociotechnical domains, the focus on short-term cost considerations at the expense of human-centering considerations always comes with a hefty price down the road. This price weighs much more heavily on users' shoulders than on those of the technologists or project managers.

Hoffman, R. R., Feltovich, P. J., Ford, K. M., Woods, D. D., & Feltovich, A. (2002). A Rose by Any Other Name ... Would Probably Be Given an Acronym. IEEE Intelligent Systems, July-August, 72-79.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
In this essay, we concern ourselves with characterizations of the "new" approaches to the design of complex sociotechnical systems, and we use a biological classification scheme to organize the discussion. Until fairly recently the design of complex sociotechnical systems was primarily known as cognitive engineering or cognitive systems engineering (CSE), a term introduced in the 1980s to denote an emerging branch of applied cognitive psychology.
Research focused on such topics as human–computer interaction, the psychology of programming, display design, and user friendliness. Although some have sought to make the term cognitive engineering seem less of an oxymoron by doing work that somehow looks like actual engineering, a number of new terms have emerged, all of which might be considered members of the "genus" Human-Centered Computing. Researchers, research organizations, funding sources, national study groups and working groups, and even entire national funding programs espouse these approaches. A number of varieties have entered the judging competition.
This variety has come about for many reasons. Some individuals have proposed terms to express views that they believe are new. Others have proposed terms as a consequence of the social and competitive nature of science and science funding, leading to turf wars and the need for individuals to win awards and claim niches that set themselves and their ideas apart from the crowd. The obvious, and obviously incorrect, question is, "Which term is the right one?" As we hope to suggest in this essay, this question is rather like the quest for the blue rose. Using the rose metaphor, and taking some liberties with Latin, we organize the essay around a set of "genuses" into which the individual "varieties" seem to fall.

Hoffman, R. R., & Hanes, L. F. (2003). The Boiled Frog Problem. IEEE Intelligent Systems, July, pp. 68-71.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
They say that a frog placed in boiling water will protest vigorously, but one placed in cool water that is slowly brought to a boil will languish happily until it is ready to be a puree. We use this as a metaphor to discuss an outstanding problem in knowledge management—a problem that human-centered computing can perhaps address. In all complex sociotechnical workplaces, including those in government and industry, knowledge and skill have become widely recognized as increasingly important assets. They are important because expertise is a "must" for proficient performance in these domains. Furthermore, this importance is increasing as we recognize that many of the most knowledgeable personnel are nearing retirement, and there are adverse consequences associated with losing their expertise. An outright panic attack comes when an organization realizes that it does not have a plan for capturing the valuable knowledge about to be lost. Like the frog languishing happily, management will languish happily until it realizes that it is getting into "very hot water" because of a loss of expertise. Widespread recognition of the boiled frog problem is apparent in the current popularity of the phrases knowledge preservation and knowledge management, as Gary Klein discussed in his seminal paper, "Using Knowledge Engineering to Preserve Corporate Memory." Many organizations have discovered—either the hard way or too late—that expert wisdom is a corporate asset. For example, NASA encountered problems owing to its loss of engineering expertise from the Apollo era. Similarly, a retiring supervisor at a large soup manufacturing firm possessed a unique skill for controlling the large soup-making machines. On the verge of his retirement, the company realized no one could do what he did, so they brought in a team of knowledge engineers to elicit and preserve his skills.

Hoffman, R. R., Hayes, P., Ford, K. M., & Hancock, P. (2002). The Triples Rule. IEEE: Intelligent Systems, pp. 62-65.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Afundamental stance taken in human-centered computing is that information-processing devices must be thought of in systems terms. At first blush, this seems self-evident. However, the notion has a long history, and not just in systems engineering.

Hoffman, R. R., Klein, G., & Laughery, K. R. (2002). The State of Cognitive Systems Engineering. IEEE: Intelligent Systems, 73-75.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
The widespread introduction of the personal computer, beginning about 1970, helped spawn the field of inquiry called cognitive engineering, which concerns itself with such things as interface design and user friendliness. Since then, this field has taught us many important things, including two major lessons.
First, the road to user-hostile systems is paved with designers' user-centered intentions. Even smart, clever, well-intentioned people can build fragile, hostile devices that force the human to adapt and build local kludges and workarounds. Worse still, even if you are aware of this trap, you will still fall into it.
Second, technology developers must strive to build truly human-centered systems. Machines should adapt to people, not the other way around. Machines should empower people. The process of designing machines should leverage what we know about human cognitive, perceptual, and collaborative skills.

Hoffman, R. R., Lee, J. D., Woods, D. D., Shadbolt, N., Miller, J., & Bradshaw, J. M. (2009). The Dynamics of Trust in Cyberdomains. Institute for Human and Machine Cognition; IEEE Intelligent Systems, pp. 5-11.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
All economic, social, and legal interactions are based on assumptions that individuals can verify identities; that they can rely on rules, institutions, and normative practice; and that they can be assured that their private space will remain protected. Monitoring, managing, verifying, auditing, and enforcing these assumptions are difficult online.

Hoffman, R. R., & Lintern, G. (2006). Chapter 12. Eliciting and Representing the Knowledge of Experts. In A. Ericsson, N. Charness, R. Hoffman, & P. Feltovich (Eds.), Cambridge Handbook on Expertise and Expert Performance. New York: Cambridge University Press.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section
knowledge elicitation, expert systems, intelligent systems, methodology, Concept Maps, Abstraction-Decomposition, critical decision method

Summary abstract:
The transgenerational transmission of the wisdom of elders via storytelling is as old as humanity itself During the Middle Ages and Renaissance, the Craft Guilds had wellspecified procedures for the transmission of knowledge, and indeed gave us the developmental scale that is still widely used: initiate, novice, apprentice, journeyman, expert, and master (Hoffman, 1998). Based on interviews and observations of the workplace, Denis Diderot (along with 140 others, including Emile Voltaire) created one of the great works of the Enlightenment, the 17 volume Encyclopedie (Diderot, 1751-1772), which explained many "secrets" - the knowledge and procedures in a number of tradecrafts. The emergent science of psychology of the 1700S and 1800s also involved research that, in hindsight, might legitimately be regarded as knowledge elicitation (KE). For instance, a number of studies of reasoning were conducted in the laboratory of Wilhelm Wundt, and some of these involved university professors as the research participants (Militello & Hoffman, forthcoming). In the decade prior to World War I, the stage was set in Europe for applied and industrial psychology; much of that work involved the systematic study of proficient domain practitioners (see Hoffman & Deffenbacher, 1992).
The focus of this chapter is on a more recent acceleration of research that involves the elicitation and representation of expert knowledge (and the subsequent use of the representations, in design). We layout recent historical origins and rationale for the work, we chart the developments during the era of first-generation expert systems, and then we proceed to encapsulate our modern understanding of and approaches to the elicitation, representation, and sharing of expert knowledge. Our emphasis in this chapter is on methods and methodological issues.

Hoffman, R. R., Lintern, G., & Eitelman, S. (2004). The Janus Principle. IEEE: Intelligent Systems, 78 - 80.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
The real Janus (Ianua) may have been an ancient king from Greece who encouraged his (adopted or conquered) people of Latium (now, a part of Italy) to acquire the skills of agriculture, industry, art, and religion. Over time, the Roman myth arose of a god who brought all things into the world, from the seasons to the ways of civilization. This god of gates and doorways opened and closed all things, including the gates of heaven. Janus was symbolized as a two-faced god, one face being that of a youth, the other of an elder. In his left hand, the youth held a key to open the gates. In his right, the elder held a scepter to master all comings and goings. We find here an allegory to the apprentice-expert continuum in the acquisition of knowledge, and so we name a principle of human-centered computing after Janus. This principle deals with the distinction between performance and training, and its implications for intelligent technologies.

Hoffman, R. R., Marx, M., Amin, R., & McDermott, P. L. (2009). Chapter 6. How Good Is That New Software Tool? The Mathematical Modeling of Performance Metrics. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section I. Collecting, Processing and Distributing Battlefield Information: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision

Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
This chapter presents a method for evaluating performance using cognitively-inspired Advanced Decision Architectures and decision support tools. The method can aid evaluators at test centers and cognitive scientists who adopt a systems-level approach to evaluation. The warfighter can benefit by receiving tools that better support cognitive functioning and situation awareness. In particular, we are interested here in measuring the learnability of new software-supported work processes and the resilience of the work to disruption.

Hoffman, R. R., Marx, M., Amin, R., & McDermott, P. L. (2009). Measurement for Evaluating the Learnability and Resilience of Methods of Cognitive Work. Theoretical Issues in Ergonomic Science (in press).

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
cognitive work, performance measurement, learnability, range statistics, technology evaluation, resilience

Summary abstract:
Some experiments on human-computer interaction are aimed at evaluating hypotheses concerning cognitive work. Other experiments are intended to evaluate the software tools that shape the cognitive work. In both cases, effective experimentation is premised on the control and factorial analysis of sources of variability. This entails programs of experimentation. However, sociotechnical systems are generally a "moving target" in terms of the pace of change. Our objective was to create a general approach to experimental design and the measurement of cognitive work that can satisfy the requirements for experimentation and yet can also provide a "fast track" to the evaluation of software-supported cognitive work. We present a measure called i-bar, which is the inverse of the mid-range. The statistic is derived from data on trials-tocriterion in tasks that require practice and learning. We interpret this single measure as a conjoint measurement scale, permitting (a) evaluation of sensitivity of the principal performance measure (which is used to set the metric for trials to criterion), (b) evaluation of the learnability of the work method (i.e., the goodness of the software tool), and (c) evaluation of the resilience of the work method. We show that it is possible to mathematically model such order statistics, and derive methods for estimating likelihoods. This involves novel ways of thinking about statistical analysis for discrete non-Gaussian distributions. The idea and method we present should be applicable to the study of the effects of any training or intervention, including software interventions designed to improve legacy work methods and interventions that involve creating entirely new cognitive work systems.

Hoffman, R. R., Marx, M., & Hancock, P. (2008). Metrics, Metrics, Metrics: Negative Hedonicity. IEEE: Intelligent Systems, 69-73.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Intelligent technologies such as performance support systems and decision aids represent a key aspect of modern sociotechnical systems. When new tools are introduced into the workplace, they represent hypotheses about how cognitive work is expected to change.1,2 The tacit hypothesis is that any such change will be for the better,

performance will be more efficient, and decisions will be improved— that is, they'll be made faster and on the basis of greater evidence. Experience suggests that technological interventions sometimes have the intended positive effect. However, they often result in negative effects, including unintended cascading failures and worker frustration due to "user-hostile" aspects of interfaces.3
Concern is rising about the high rate of software procurement failures that are due to the inadequate consideration of human factors. Recent statistics suggest a dismal record, representing the expenditure of billions of dollars for technologies that are unusable, ineffective, and at times even defunct.4,5 At the same time, funding for developing communication and information technologies has reached record levels (about US$500 billion in the mid-1990s).6 Recently we've seen entire government-sponsored research programs with titles that state human–system integration as a key goal for new technologies.7 The notorious frustrations and failures triggered by software interventions in the workplace have led to a significant concern in the software engineering community with evaluation,8,9 including help for organizations to establish metrics for "key performance indicators."10,11

Hoffman, R. R., & McNeese, M. D. (2009). A History for Macrocognition. Journal of Cognitive Engineering and Decision Making, 3, 97-110.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
This article presents a historical context for the current notion of macrocognition. The idea of macrocognition has precedents dating to the first decades of experimental psychology. The distinction between macrocognition and microcognition instantiates philosophical issues that contrast structuralism with functionalism (naturalism and holism). This is one of the thematic "pendulum swings" across the history of psychology. With regard to both experimentation and computational modeling, the issues that persist across history can be interpreted as cautionary tales, as constraints on methodologies, or as challenges.

Hoffman, R. R., & Militello, L. G. (2009). Perspectives on Cognitive Task Analysis: Historical Origins and Modern Communities of Practice Boca Raton, FL: CRC Press/Taylor and Francis.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book

Summary abstract:
The purpose of this book is to provide a context for understanding Cognitive Task Analysis (CTA) in terms of its historical roots and recent origins in the traditional disciplines and emerging communities of practice. In the chapters of this book, we show how CTA came to be what it is today. We show where the many CTA methods have come from and what they are intended to do. We also provide integration by showing the relations, dovetailings, common themes, and common purposes of the various disciplines that have contributed to our modern understanding of CTA. We especially focus on the convergence with regard to the design of information systems, including intelligent technologies.
This book is intended to be a companion to Working Minds: A Practitioner's Guide to Cognitive Task Analysis (Crandall, Klein, & Hoffman, 2006), which goes into detail about the actual conduct of CT A methods. This book can also be seen as having a companion-Neville Moray's History and Scope of Human Factors (2005), which reprints many of the classic writings that are cited and encapsulated in this Perspectives book, including works by John Annett, Frederick Gilbreth, Donald Norman, Jens Rasmussen, David Woods, the classic paper on "man-machine task analysis" by R. B. Miller, and others.

In addition to providing a summary at the end of each chapter, we included an advance organizer at the beginning of each chapter. These organizers take the form of "Concept Maps" that layout the key ideas. As concept mapping spreads around the world in its various applications in research, education, and Web work (see Canas et ai., 2003; Canas & Novak, 2006; Hoffman, Coffey, Novak, & Canas, 2005; Hoffman & Lintern, 2006; Novak, 1998), we present here a somewhat novel use of Concept Maps-to serve, in effect, as executive summaries. Learn more about CmapTools (including the research background) and get a free download at http://www.ihmc.us. A detailed "how-to" discussion of the use of Concept Maps as a knowledge elicitation method for creating knowledge models is in Crandall, Klein, and Hoffman (2006, chap. 4).
That Was Then
Those who came before us were more aware of the key issues and arguments than we might give them credit for. Indeed, many modern researchers have reinvented the wheel and given it new names, often believing their work is distinct or special. In fact, Fernberger (1937) acknowledged that sporadic amnesia is inevitable:
Scientific ideas become public and common property in spite of anything one may do .... Examples of particular processes and modes of explanation become current in a laboratory and one does not remember whether one thought of them himself or whether they should be attributed to some one of one's colleagues. (p. xi)
One goal of this book is to draw connections from past approaches to current methods, tracing the historical roots of modern Cognitive Task Analysis (CTA), tracing the pendulum swings, the divergences and convergences. We hope that for a next generation this will reduce the need to reinvent the wheel and encourage efforts to improve on the wheels we already have.
Although we are hesitant to overly constrain the notion of CTA, we think it is necessary to place some boundaries around which approaches will be examined. First off, we need to look at the meaning of the word task.

Hoffman, R. R., Norman, D. O., & Vagners, J. (2009). “Complex Sociotechnical Joint Cognitive Work Systems”? . IEEE: Intelligent Systems, 82-89.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
This essay continues a tradition in this department: deconstructing the meanings of various buzz phrases.”1 It calls out a cluster of phrases that use the word system.
Kinds of Systems? Consider the following six systems-related terms.
Sociotechnical systems emerged from research at the Tavistock Institute in the 1950s on the effects of the introduction of powered machines on the work, management-labor relations, and the lives, families, and societies of coal miners.2
Human-machine systems is the idea, originating in industrial psychology in the World War I era, that man and machine must be thought of as a single system. The tipping point was the design of a new machine tool’s clutch, which required more force than a human lathe operator could muster. The engineers had to learn to design the human-machine as the unit of analysis. Researchers developed this idea further during World War II in work on control theory and cybernetics.3 Use of the term system expanded after around 1950.4
Researchers have used the term complex systems to emphasize the importance of systems theory and issues of complexity in engineering and design.5
Human-system integration is the new kid on the block, initially a refl ection of the US Navy’s interest in reducing the crew complement on ships. More recently, the concept expanded in the systems engineering community to refer not only to the traditional goals of human factors such as safety, trainability, and reliability but also to such issues as usability, usefulness, and resilience (the key concerns of cognitive systems engineering).6
Joint cognitive systems describes this same general subject matter, with “joint” intended to focus on humans working collaboratively with information technology.7
Researchers at the Institute for Human and Machine Cognition proposed complex cognitive systems as the name of a theory based on the idea that we can reinterpret the “principles” of human- centered computing as empirical nomological generalizations—that is, scientifi c laws.8

All these terms relate directly and immediately to human-centered computing. Their point is to create technology and work methods that improve work processes and results, while also improving the human condition.
Since the notion of systems theory became coin of the realm, we've added many mod ifi ers onto the word "systems." For example, some scholars refer to "dynamical systems," some to "large-scale systems." Both phrases are thought of as differing from run-of-the-mill systems.9 "Self-organizing" systems are also considered more than plain old systems, in that they increase in complexity without an external guiding hand. Entire theories are built upon the notion of self-organization, largely (and perhaps not surprisingly) in biological systems. 10−12 Likewise, there are formidable theoretical scaffolds discussing "adaptive systems."13
Beyond their use as favored terms of particular disciplines and the carriers of historical baggage, what value or meaning do we add by prefixing "system" with any of these modifiers?

Hoffman, R. R., Roesler, A., & Moon, B. M. (2004). What Is Design in the Context of Human-Centered Computing? IEEE Intelligent Systems(July/August), 89-95.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Problem solving often involves recognizing and fiddling with tacit assumptions. Such realization can often come from seeing things from new perspectives. Appreciating the human-centered perspective may offer some hope for enriching design's scientific foundations and for crafting new and better approaches to it. Essays in this department have introduced such notions as the Sacagawea Principle:2

Human-centered computational tools need to support active organization of information, active search for information, active exploration of information, reflection on the meaning of information, and evaluation and choice among action sequence alternatives. Certainly this suggests a constraint on or a goal for design, but how do we go from such statements to actual designs that accomplish the stated goals?

We approach this class of question by considering the origins of and historical influences on the notion of design, then by considering the assumptions underlying our modern conception of design in light of the principles of human-centered computing.

Hoffman, R. R., & Shattuck, L. G. (2006). Should We Rethink How We Do OPORDs? Military Review, March-April, 100-107.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
The U.S. Army has used a structured order format and process for more than 80 years. The 1924 version of the Field Service Regulation prescribed "formatted orders, with annexes, maps, and tables."1 Staff procedures have evolved since then, but the basic structure of the operation order (OPORD) has remained essentially the same—five paragraphs or sections that describe the situation, mission, execution, service support, and command and signal. The basic process for creating, sharing, and using OPORDs has also remained essentially the same and is "time-consuming and effortful." It needs to be revised.2
OPORDs begin when a higher echelon communicates its OPORD to a lower echelon. The lower echelon commander and staff review the OPORD and conduct a mission analysis. The lower level commander provides guidance to the staff, and the staff enters into the military decisionmaking process. Typically, the staff presents the

commander with multiple courses of action (COAs), the commander chooses one COA and expresses his intent, the staff creates an OPORD and passes it to the next lower echelon, and the process is repeated until all Soldiers have been told what is expected of them. OPORDs are also passed back up for an iterative sweep through the echelons and final approval.
OPORDs can sometimes be hundreds of pages long. However, clear, concise communication, especially of the commander's intent, is a critical aspect of military planning, replanning, and operations. The effort devoted to training in writing and interpreting OPORDs in the Reserve Officer Training Corps, at the U.S. Military Academy, and throughout the U.S. Army Training and Doctrine Command school system indicates how important this is.3
Having recently evaluated OPORDs and conducted empirical studies of how OPORDs are understood, we propose a change to the existing OPORD format and a new procedure for creating OPORDs, to amplify adaptive decisionmaking at all echelons and improve planning for joint and coalition operations.

Hoffman, R. R., & Woods, D. D. (2005). Toward a Metatheory for the Theory of Complex Cognitive Systems. In IEEE.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Essays in this department have presented nine propositions that we've referred to as principles of humancentered computing:
• The Aretha Franklin Principle: Do not devalue the human in order to justify the machine. Do not criticize the machine in order to rationalize the human. Advocate the human-machine system in order to amplify both.1
• The Sacagawea Principle: Human-centered computational tools need to support active organization of information, active search for information, active exploration of information, reflection on the meaning of information, and evaluation and choice among action sequence alternatives.2
• The Lewis and Clark Principle: The human user of the guidance needs to be shown the guidance in a way that is organized in terms of his or her major goals. Information needed for each particular goal should be shown in a meaningful form, and should allow the human to directly comprehend the major decisions associated with each goal.2
• The Envisioned World Principle: The introduction of new technology, including appropriately human-centered technology, will bring about changes in environmental constraints (that is, features of the sociotechnical system, or the context of practice). Even though the domain constraints might remain unchanged, and even if cognitive constraints are leveraged and amplified, changes to the environmental constraints might be negative.3
• The Fort Knox Principle: The knowledge and skills of proficient workers is gold. It must be elicited and preserved, but the gold must not simply be stored and safeguarded. It must be disseminated and utilized within the organization when needed.4
• The Pleasure Principle: Good tools provide a feeling of direct engagement. They simultaneously provide a feeling of flow and challenge.5 • The Janus Principle: Human-centered systems do not force a separation between learning and performance. They integrate them.6
• The Mirror-Mirror Principle: Every participant in a complex cognitive system will form a model of the other participant agents as well as a model of the controlled process and its environment.7
• The Moving Target Principle: The sociotechnical workplace is constantly changing, and constant change in environmental constraints might entail constant change in cognitive constraints, even if domain constraints remain constant.3
The term "principle" doesn't actually do much work in science. Colloquially, it's used as a tacit reference to laws, as in "This device works according to the principle of gravity." What are these so-called principles? Our answer leads to additional considerations involving the use of the principles.

Hoffman, R. R., & Yates, J. F. (2005). Decision(?)-Making(?). IEEE: Intelligent Systems, 22-29.

Key Words:
ADA CTA
Advanced Decision Architectures

Collaborative Technology Alliance
Journal Article

Summary abstract:
Consider, for a moment, “What are we making intelligent decision aids for?” Computers, including intelligent systems, assist human decision making in many ways.1–3 Decision aids can range from an online tool provided by Consumer Reports to help people choose a refrigerator, to a large system for monitoring an industrial process. Group decision aids focus on supporting communication.4,5 Expert systems can be considered decision aids, as can systems that use statistical methods to assist in diagnostic procedures. Decision aids can provide information involved in deciding or information pertinent to evaluating states of the world. To support these situation assessment and monitoring activities, computers can integrate and display information and assist in replanning.6 When we deconstruct such generic tasks, most of the component tasks reduce to option generation, option selection, and outcome evaluation.7 For these, we can bring to bear various mathematical techniques such as utility analysis.8
But how well do such tools really help humans deal with the difficulties of deciding itself—for instance, adapting to changing circumstances or coping with situations that are both unfamiliar and infrequent?7 While several good analyses of decision-making situations and situational factors exist that can help shape decision-aid architectures and functionalities,9,10 has anyone done a corresponding analysis of what this thing called the decision is? After discussing this question, we’ll sharpen the focus for new and potentially useful applications of intelligent systems technologies.

Hoffman, R. R., Zachary, W., Burns, J., Drillings, M., Hale, C. R., & Linegang, M. (2008). Panel Discussion: Human Total Cost of Ownership: Measuring the Impact of Human Factors on System Engineering. In In Proceedings of 52nd Annual Meeting of the Human Factors and Ergonomics Society. 22-26 September 2008. New York City, NY USA. New York City, NY USA: HFES.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The procurement process often results in information systems that are of limited usefulness, usability and understandability. A focus on short-term cost of acquisition, as a main driving force in procurement, always comes with a hefty price that weighs most heavily on the shoulders of those who have to conduct cognitive work using the new technologies. Procurement that is driven primarily by Designer-Centered Design and the goal of reducing immediate cost fails because it does not recognize the value of the human component. Zachary et al. (2007) proposed a new family of measures for use in procurement, referred to collectively as Human Total Cost of Ownership (HTCO). HTCO might be defined in a number of ways, and from the conceptual definitions one might generate a number of operational definitions of how to actually calculate metrics. Panelists will address the overarching questions of HTCO measures and their integration into the acquisition and development process, current obstacles to Human-Centered Design, ways in which HTCO might gain entry into the procurement process, and alternative approaches to creating specific HTCO measurables.

Hollnagel, E., & Woods, D. D. (2005). Joint Cognitive Systems: Foundations of Cognitive Systems Engineering.: Taylor & Francis.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book

Summary abstract:
Deciding what to write in a preface is not as easy as it seems. If there is anything of substance to say about the subject matter, it should clearly be in the main text of the book rather than in the preface. And if there is nothing of substance to say, then why say it? Prefaces can therefore easily become the place where the authors write their more

personal views on matters large and small, express their gratitude to various people, and lament about the state of the world in general. Prefaces can also become the authors' encomium for their own work. Publishers welcome that, since it can be put on the back cover or on the website, but common decency usually intervenes in time.
After this beginning there are pretty few options left for us, except to briefly reminisce on how this book came about. The collaboration between the two authors began around 1979 and soon led to the ideas that became formulated as cognitive systems engineering (CSE), first in an internal report in 1982, and later as a paper in the International Journal of Man-Machine Studies. About ten years later, in the beginning of the 1990s, we started talking about writing a book on CSE. One motivation was that the idea seemed to have caught on; another was that we by that time individually and together had produced a number of writings that both had developed the original ideas further and illustrated how they could be applied in practice.
The route from word to deed is, however, usually longer than initially hoped for. While the intention to write a book together was never abandoned, progress was painfully slow, partly because we both had entangled ourselves in too much interesting work, and partly because the much coveted opportunity to sit down together for a couple of weeks on a desert island never quite materialised.
In the end the book became a reality because we adopted a pragmatic solution - in good according with the ethos of CSE. Instead of writing one book together, the project was split into two parts, leading to two books that complement each other. While we appear as joint authors of either book, the order differs to reflect the fact that the first author in each case is the main responsible for the writing. This also helps to solve the practical problem that a single book would have been rather large. Furthermore, we had over the years developed different styles of working and writing, one being more contemplative, the other being more practical.
The end result is therefore not one but two books of which this is the first. Both books are entitled Joint Cognitive Systems with the subtitles indicating the specific focus - and therefore also what distinguishes them from each other. The subtitle of the present book is 'Foundations of Cognitive Systems Engineering', while the subtitle of the second book is 'Patterns in Cognitive Systems Engineering'. The intention is that either book can be read independently, but that they also will complement each other by emphasising the theoretical and the practical aspects respectively. It is no requirement that they are read in a specific order. Yet if people after reading either one would find it necessary to read also its counterpart, we would feel we had achieved our purpose.

Holzapfel, H., Fuegen, C., Denecke, M., & Waibel, A. (2003). Integrating Emotional Cues into a Framework for Dialogue Management. In In Proceedings of the Fourth IEEE International Conference on Multimodal Interfaces (ICMI'02). Pittsburgh, PA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Emotions are very important in human-human communication but are usually ignored in human-computer interaction. Recent work focuses on recognition and generation of emotions as well as emotion driven behavior. Our work focuses on the use of emotions in dialogue systems that can be used with speech input or as well in multi-modal environments.
This paper describes a framework for using emotional cues in a dialogue system and their informational characterization. We describe emotion models that can be integrated into the dialogue system and can be used in different domains and tasks. Our application of the dialogue system is planned to model multi-modal human-computer-interaction with a humanoid robotic system.

Howard, M. V., & Woods, D. D. (2002). The 'Squidgy': An Order of Magnitude Display. In In Proceedings of Eleventh European Conference on Cognitive Ergonomics (ECCE-11). Catania, Sicily.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Visualization, representation design.

Summary abstract:

This paper presents a display approach aimed at visualizing scales and ranges that span many orders of magnitude, with a focus on retaining qualitative aspects of non-linear scales. This was achieved by the linking of linear and non-linear frames of reference and allowing the user to explore this link interactively through the dynamic reference of the representation. The approach taken is one which is theoretically well grounded and empirically user validated, to provide re-usable design seeds for future development. The user validation was targeted at eliciting what 'usefulness' means for such a representation and was conducted as a series of indepth, qualitative interviews focussing future situations of use where such a representation may be available. Results show that the key aspects of usefulness are the tight coupling of the frames of reference, high dynamic character and responsiveness of the interaction, but also that 'usefulness' has both a cognitive and domain component which interact in subtle and complex ways.

Hughes, T., Warwick, W., Banks, S., & Garrambone, M. (2006). Human Behavior Representations: Reflections on a Decade Past. In Presented as part of a part of a panel discussion for the Research Development and Engineering Forum, Fall 2006 Simulation Interoperability Workshop. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Panel Charter
ØWhat has been accomplished over the past decade?
ØAre we still tracking to the objectives as articulated in the 1995 M&S Master Plan?
ØAre the 1995 objectives still valid?
ØWhat challenges remain?

Hutchins, S., Cosenzo, K. A., McDermott, P. L., Feng, T.-d., Barnes, M., & Gacy, M. (2009). An Investigation of the Tactile Communications Channel for Robotic Control. In In Proceedings of 53rd Annual Meeting of the Human Factors and Ergonomics Society, San Antonio, TX.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The impacts on performance of three different forms of communication (radio, chat, and tactile belt) were explored in the context of a small unmanned ground vehicle (SUGV) target identification task. The target identification task required a Commander with knowledge of target locations and access to a digital map displaying the current SUGV position and orientation to direct a Soldier remotely operating the SUGV to the targets using a finite set of eleven commands. The study revealed no evidence for a loss of soldier performance with the tactile belt communications channel. The finding suggests that the tactile use of haptic signals may be feasible, a potentially important finding for situations requiring covert communications.

Hutchins, S., Josephson, J. R., Barnes, M., Chandrasekaran, B., McDermott, P. L., & Miller, T. N. (2009). Chapter 11. An Interactive Decision Support Architecture for Visualizing Robust Solutions in High-Risk Military Environments. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section II. Presenting Battlefield Information to Warfighters: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
The economic climate in 2009 is an important reminder of the crucial role that risk perception and risk misperception play in decision making that impacts everyday life. Many of the economic decisions such as percent of acceptable subprime mortgages were actually based on complex statistical models using overly optimistic assumptions. Military decision making is also replete with examples of overconfidence in the assumptions of decisions, i.e., assumptions that are the product of risk perception and/or risk misperception by otherwise competent commanders that ultimately result in disaster. Examples include McArthur's refusal to believe the Chinese would attack across theYalu River during the Korean conflict, Montcalm's decision in 1759 not to defend his rear flank against Wolfe because of the supposedly impregnable cliffs of Quebec City, and the Maginot Line fiasco in World War II.

Our research focuses on instances where reality does not match the assumptions upon which decisions were made. We developed decision tools in the form of graphical visualizations and human-computer interaction methods that would help junior commanders understand the consequences of various courses of action (COAs). Decisions that result in successful outcomes under a variety of supportable assumptions operationally define our concept of robustness. In Chandrasekaran (2008) it is argued that, in contrast to the traditional emphasis on optimality, planning should aim to produce plans that are robust, i.e., plans that have satisfactory performance even when reality fails to match the assumptions and models used in planning. Our decision tools do not lead to a single optimal solution but rather to a set of possible solutions. The final decision is left to the commander based on his/her instincts and weightings of various military criteria (e.g., speed versus sensor coverage). Our tools are designed to impart insight rather than be prescriptive in nature.

Most traditional decision research approaches model uncertainty in the world probabilistically and offer solutions that are adequate on average. The traditional approaches also assume a defined probability space and a rational actor. Both assumptions can be misleading. First, much of the uncertainty in the world cannot be modeled in a fully defined problem space. Second, Kahneman and Tversky (1979) and other researchers in behavioral economics conducted numerous studies indicating that humans do not necessarily follow normative models. In general, the results indicate humans use bounded rational solutions or heuristics that are expedient but also subject to bias. In particular, humans often misinterpret and misuse probabilistic estimates related to risky decisions. The point is not that humans make poor decisions; rather, they usually do not make them based on defined probability spaces. The simple probability models that define the problem spaces may be inappropriate, or even incomplete, for complex dynamic systems. In many combat situations outcome probabilities change rapidly, requiring flexible real-time replanning as the situation unfolds rather than dependence on a single optimal solution. Robust decisions remain sufficient even when reality is not as expected because robust decisionmaking acknowledges that models ofthe world are incomplete and human decision making is error-prone.

The research described is an attempt to understand the interplay between robust solutions, normative models, and the ability of the military planner to understand the risk environment. Our research assumes the commander will base his/her decisions on multiple cues with relative importance that will change as the combat environment changes. Based on that assumption, we anticipate commanders will develop more robust solutions if they are able to understand various decision outcomes and their consequences. We additionally expect that planning time will be reduced with tools that allow the operator to filter unreasonable solutions, circumventing the computational explosion inherent in any decision tree.

The uncertainty of the real world poses a variety of challenges in the design of decision support systems (055). Decision support systems attempt to mediate uncertainty through decision tools such, such as those examined, here toward robust decisions. Contingency planning against the most likely events or intentions is sometimes appropriate for dealing with uncertain situations. Other times, uncertainty may be addressed by simply exploring the robustness of selected plans and understanding how the plan may perform if reality does not quite match the planning assumptions. For example, a robust plan would provide good coverage even when the actual enemy avenue of approach turns out to be different from that assumed for planning. A plan is also robust if it provides good coverage when some of the sensors fail, either en route or during surveillance. The risks and uncertainties need to be presented to the planner in a way that is meaningful and protective against biases. While decision support is often couched in terms of making an optimal decision, helping the decision maker understand the decision space (i.e., develop a sense of relations between decision variables and outcomes in different parts of the decision space) is equally, if not more important. If after the selected plan is implemented external events call for rapid replanning, then the planner can exploit his/her understanding of the decision space to rapidly and effectively respond.

To investigate the concept of robustness for risk management, we chose a sensor allocation problem. In addition to being a vehicle for exploring robust decision making, the problem is also intrinsically important militarily and

relates to other problems such as persistent surveillance, border incursions, and force protection. The sensor allocation problem is a good application of one of our research goals: how to present interactive information to planners that allows them to understand the consequences of various courses of action while maintaining flexible options in cases of sudden combat reversals.

Hutchins, S., McDermott, P. L., & Barnes, M. (2008). Frame Consistency in Multi-Attribute Risk Preference Decisions. In In Proceedings of 52nd Annual Meeting of the Human Factors and Ergonomics Society. 22-26 September 2008. New York City, NY USA. New York City, NY USA: HFES.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Resource allocation under risk and uncertainty is a complex problem, specifically when making course of action planning decisions on the battlefield. Previous research in this domain has demonstrated the performance impact of visualization aids, feedback, practice, information frame, and time pressure. However, the focus of prior research has been on how to help operators determine where to optimally place a single asset. The current research addressed the same domain, but with the multi-attribute decision of how to best allocate a suite of robotic assets across the battlefield. We explored the impact of information frame and time pressure on decision performance and situation awareness, but further manipulated whether the information frame of decision criteria were forced to a single consistent frame or allowed to vary according to which term was intuitive, regardless of frame. We found both faster response times and more accurate responses within consistently-framed displays over mixed-frame displays. In addition, response time varied less in the consistently-framed displays than the mixed-frame displays.

Hutton, R., Stanard, T., Warwick, W., & McIlwaine, S. (2003). Computationally Modeling Recognition-Primed Decisions: Conceptual Insights. In In Proceedings of Fairborn, OH CTA Conference: Klein Associates Inc.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
•RPD Primer
•High level phenomenon vs. processes and mechanisms
•What is a decision?
•What is recognition?
•Expert/novice differences in RPD
•What are expectancies? How do they relate to mental models and mental simulation?
•Do simulation environments support perceptual/cognitive activities of simulated agents?

Summary abstract:
RPD Primer
•Describes how experts make good decisions in tough situations•Emphasis on situation assessment
•Emphasis on experience and recognition based on typicality
•Emphasizes decision cycles vs. choice points
•Emphasis on satisficing
•Emphasis on mental simulation of plausible options (not concurrent evaluation of candidate courses of action

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Hutton, R. J. B., Miller, T. E., & Thordsen, M. L. (2003). Chapter 17. Decision Centered Design: Leveraging Cognitive Task Analysis in Design. In E. Hollnagel (Ed.), Handbook of Cognitive Task Design (pp. 383-416). 10 Industrial Avenue, Mahwah, New Jersey 07430: Lawrence Erlbaum Associates, Inc. Also In Proceedings of XVth Triennial Congress of the International Ergonomics Association. Seoul, Korea.

Key Words:
ADA CTA
Advanced Decision Architectures

Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Decision-centered design (DCD) is a design approach that focuses on understanding and supporting cognitive tasks. Research in the areas of naturalistic decision making and expertise has provided the cognitive models and analytic methods that enable this approach. DCD provides a means for communication and understanding between designers and the individuals for whom interventions are being designed. It targets the critical, often challenging cognitive tasks confronting these individuals, including individual tasks in which cognitive performance may break down and teamlevel tasks that require collaboration and coordination. The approach consists of task analysis, design, and evaluation.

Iyer, N. S., & Josephson, J. R. (2001). Multicriterially Best Explanations. In K.P. Jantke and A. Shinohara (Eds.), Discovery Science, Lecture Notes in Artificial Intelligence 2226, Pp. 128-140. Also in Proceedings of Discovery Science 2001: The 4th International Conference on Discovery Science. Washington Dc, 2002. New York, NY: Springer Verlag. ISBN 3-540-42956-5.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Inference to the best explanation, IBE, (or abduction) requires finding the best explanatory hypothesis, from a set of rival hypotheses, to explain a collection of data. The notion of best, however, is multicriterial and the available rival hypotheses might be variously good according to different criteria. Thus, one can view the abduction problem as that of choosing the best hypothesis from among a set of multicriterially evaluated hypotheses - i.e as a multiple criteria decision making problem (MCDM). In the absence of a single hypothesis that is the best along all dimensions of goodness, the MCDM problem becomes especially hard. The Seeker-Filter-Viewer architecture provides an effective and natural way to use computer power to assist humans to solve certain classes of MCDM problems. In this paper, we apply an MCDM perspective to the abductive problem of red-cell antibody identification and present the results obtained by using the S-F-V architecture.

Jefferson, T., Jr., Ferzandi, L., & McNeese, M. (2004). Assessing the Impact of Hidden Knowledge Profiles on Distributed Cognition and Team Decision-Making: Recounting the Development of the Neocities Simulation. In In Proceedings of 48th Annual Meeting of the Human Factors and Ergonomics Society. New Orleans, LA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This study continues research from McNeese (2000) and was designed to examine the effects of hidden knowledge profiles on perceptually anchored team cognition and knowledge transfer in distributed teams. Previous work showed that individuals in perceptually anchored distributed teams were able to quickly access applicable knowledge, then transfer that knowledge to answer similarly situated problems. Perceptual anchors provide the basis for formulating team mental models, which can be used to assess situations and resolve differences in individual, unique knowledge. In the present experiment, it was again hypothesized that individuals working in perceptually anchored distributed teams would be better able to transfer knowledge, than teams without anchors. It was also hypothesized that perceptually anchored distributed teams would be better able to share uniquely held information, make better decisions, identify information discrepancies, and overcome the presence of hidden knowledge profiles better than non-perceptually anchored teams. Preliminary findings are discussed.

Jin, J., Rothrock, L., McDermott, P. L., & Barnes, M. (2009). Using the Analytic Hierarchy Process to Examine Judgment Consistency in a Complex Multi-Attribute Task. IEEE Transactions on Systems Man & Cybernetics, Part A Systems and Humans.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Analytic Hierarchy Process (AHP), framing effect, judgment consistency, multiattribute task.

Summary abstract:
This paper investigates the impact of framing and time pressure on human judgment performance in a complex multiattribute judgment task. We focus on the decision process of human participants who must choose between pairwise alternatives in a resource-allocation task. We used the Analytic Hierarchy Process (AHP) to calculate the relative weights of the four alternatives (i.e., C1, C2, C3, and C4) and the judgment consistency. Using the AHP, we examined two sets of hypotheses that address the impact of task conditions on the weight prioritization of choice alternatives and the internal consistency of the judgment behavior under varying task conditions. The experiment simulated the allocation of robotic assets across the battlefield to collect data about an enemy. Participants had to make a judgment about which asset to allocate to a new area by taking into account three criteria related to the likelihood of success. We manipulated the information frame and the nature of the task. We found that, in general, participants gave significantly different weights to the same alternatives under different frames and task conditions. Specifically, in terms of ln-transformed priority weights, participants gave significantly lower weights to C2 and C4 and higher weight to C3 under gain frame than under loss frame, and also, under different task conditions (i.e., Tasks #1, #2, and #3), participants gave significantly higher weight to C4 in Task #1, lower weights to C1 and C4, higher weight to C3 in Task #2, and lower weight to C3 in Task #3. Furthermore, we found that the internal consistency of the decision behavior was worse, first, in the loss frame than the gain frame and, second, under time pressure. Our methodology complements utility-theoretic frameworks by assessing judgment consistency without requiring the use of task-performance outcomes. This work is a step toward establishing a coherence criterion to investigate judgment under naturalistic conditions. The results will be useful for the design of multiattribute interfaces and decision aiding tools for real-time judgments in time-pressured task environments.

Johnson, M., Feltovich, P. J., Bradshaw, J. M. & Bunch, L. (2008). Human-Robot Coordination through Dynamic Regulation. In In Proceedings of 2008 IEEE International Conference on Robotics and Automation (ICRA-08), Pasadena, CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Several key aspects of coordination such as teamwork, roles, and communication, are enabled and driven by, and even largely defined by, various systems of regulation. One key feature of all these elements in human coordination is their dynamic nature. We have developed a framework to provide a dynamic regulatory system for supporting coordination in human-robot teamwork. This framework supports the definition and functions of roles within teams, as well as the creation of subteams and the roles within them. It also serves to regulate communications in support of coordination. We have demonstrated our system with a team of two humans and five robots performing advanced coordination while trying to apprehend an intruder hiding on a cluttered pier. This work lays the foundation for human-robot coordination based on dynamic regulation.

Johnson, M., Bradshaw, J. M., Jung, H., Suri, N. & Carvalho, M. (2008). Policy Management across Multiple Platforms and Application Domains. In In Proceedings of 2008 IEEE Conference on Policy, Palisades, NY.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
One of the challenges of building a policy management framework is making it flexible enough to handle differences in both policy semantics and enforcement strategies across multiple platforms and application domains. The system must be expressive enough in each application domain to provide the richness needed for interesting policies. It must also provide a simple and flexible enforcement mechanism for adaptation to a variety of systems. In this paper we discuss the application of the KAoS policy services framework to human-robot teamwork—an application that involves a variety of application domains and enforcement at different levels of control; from low level network resource control to high level organizational constraints and coordination management. The study culminated in an outdoor field exercise that required coordination of mixed sub teams composed of two people and five robots whose task was to find and apprehend an intruder on a Navy pier.

Johnson, M., Bradshaw, J., Feltovich, P., Jeffers, R., Jung, H., & Uszok, A. (2006). A Semantically-Rich Policy-Based Approach to Robot Control. In In Proceedings of Third International Conference on Informatics in Control, Automation, and Robotics (ICINCO 2006), Set£bal, Portugal.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Policy, semantic, authorization, obligation, ontology

Summary abstract:
In this paper we describe our approach to enhancing control of robotic systems by providing domain and policy services via KAoS. Recently developed languages such as OWL provide a powerful descriptive logic foundation that can be used to express semantically rich relationships between entities and actions, and thus create complex context sensitive policies. KAoS provides a tool to create policies using OWL and an infrastructure to enforce these policies on robots. We contend that a policy-based approach can provide significant advantages in controlling robotic systems and is a much more natural way for operators to interact with and manage multiple robots.

Johnson, M., Bradshaw, J. M., Feltovich, P. J., Jonker, C. M., & Riemsdijk, B. v. (2009). Coactive Design. Why Interdependence Must Shape Autonomy. In In Proceedings of International Conference on Engineering Societies in the Agent's World (ESAW '09), Utrecht, The Netherlands. Human-Agent-Robot Teamwork Workshop (HART).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Categories and Subject Descriptors
I.2.9 [Robotics]: Autonomous vehicles
General Terms
Design, Human Factors, Theory.
Keywords
Coactive, autonomy, interdependence, joint activity.

Summary abstract:
This paper introduces Coactive Design as a new approach to address the increasingly sophisticated roles for people and agents in mixed human-agent systems. The basic premise of Coactive Design is that the underlying interdependence of joint activity is a critical design feature. When designing the capabilities that make an agent autonomous, the process should be guided by an understanding of the interdependence in the joint activity. This understanding is then used to shape the operation of agent capabilities and enable appropriate interaction. The success of future human-agent teams hinges not merely on trying to make agents more autonomous, but also in striving to make them more capable of sophisticated interdependence

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Johnson, M., Chang, P., Jeffers, R., Bradshaw, J., Breedy, M., Bunch, L., Kulkarni, S., Lott, J., Suri, N., Uszok, A., & Soo, V.-W. (2003). KAoS Semantic Policy and Domain Services: An Application of DAML to Web Services-

Based Grid Architectures. In In Proceedings of AAMAS 03 Workshop on Web Services and Agent-Based Engineering. Melbourne, Australia.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Categories and Subject Descriptors
I.2.11 [Artificial Intelligence] Distributed Artificial Intelligence - Intelligent agents, Multiagent systems
I.2.4 [Artificial Intelligence] Knowledge Representation Formalisms and Methods - Representation languages, Semantic networks
I.2.3 [Artificial Intelligence] Deduction and Theorem Proving - Inference engines
General Terms
Management, Security, Standardization, Languages
Keywords
policy, domain, access control, authorization, KAoS. Grid Computing, Web Services, DAML, OWL, Semantic Web, Semantic Grid, description logic, software agent

Summary abstract:
This paper introduces a version of KAoS Semantic Policy and Domain Services that has been developed to support Web Services-based (i.e., OGSA-compliant) Grid Computing Architectures. While initially oriented to the dynamic and complex requirements of software agent applications, KAoS services are now being extended to work equally well with both agent and non-agent clients on a variety of more general distributed computing platforms. The OGSA-compliant version of KAoS services allows fine-grained policy-based management of registered Grid services as well as opening additional opportunities for the use of agents on the grid.

Johnson, M., Feltovich, P. J., & Bradshaw, J. M. (2008). R2 Where Are You? Designing Robots for Teamwork with Humans. In In Proceedings of ICRA 2008 Workshop on Social Interaction with Intelligent Indoor Robots (SI3R 2008), Pasadena, CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The majority of robotic systems today are designed by first building a robot that can perform some tasks, adding an interface, and then trying to figure out why the interaction is unnatural and the collaboration is non-existent. Collaboration must be designed into the system from the start. There has been a lot of work on both the interface and the autonomy ends of such systems, but the critical component to facilitate coordination lies in the middle and has had only limited attention in the robotics world. This collaborative middle layer should drive the design of both interface and autonomy. In this paper we will provide a detailed description of the type of collaboration envisioned and the characteristics associated with this type of joint activity. These will be used to establish the design requirements for collaborative humanrobot systems and present a cohesive portrait of the essential components necessary to achieve the ideal goal. In addition, some critical challenge areas are highlighted.

Johnson, M., Kulkarni, S., Raj, A., Carff, R., & Bradshaw, J. M. (2005). Ami: An Adaptive Multi-Agent Framework for Augmented Cognition. In In Proceedings of 1st International Conference on Augmented Cognition. Mahwah, NJ.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In this paper, we report on our efforts to develop an Adaptive Multi-agent Integration framework, called AMI, and its application in the development of Augmented Cognition (AugCog) systems. Key components of AMI include: 1) Pluggable sensor architecture with dynamically substitutable measures for flexible, optimal exploitation of all available multi-sensory channels; and 2) An industrial-strength integration approach and providing high

faulttolerance and dynamic workload distribution across virtually any implementation platform. AMI leverages IHMC's Knowledgeable Agent-oriented Systems (KAoS) services to provide a flexible and generic approach for linking components. For AugCog systems, these components can be for sensing, detecting cognitive state, and modulating the application itself. AMI has served as the integration platform for a large multi-institutional team led by Honeywell Laboratories under funding from DARPA's Improving Warfighter Information Intake Under Stress program. Multiple sensors and cognitive state measurement gauges have been independently developed by members of the team and straightforwardly integrated for rapid prototype development and evaluation. The flexibility of the AMI framework has been successfully demonstrated by accommodating the myriad of changes to hardware and algorithms required by the research advances achieved throughout the project.

Johnson, M. J., Intlekofer, K., Jr., Jung, H., Bradshaw, J. M., James Allen, Suri, N., & Carvalho, M. (2008). Coordinated Operations in Mixed Teams of Humans and Robots. In In Proceedings of 2008 IEEE International Conference on Distributed Human-Machine Systems (DHMS 2008). Athens, Greece.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings Robot and Human Cooperation, Team Formation, Teamwork policies, Agile Computing, Dialogue-Based Collaboration.

Summary abstract:
The goal of this research was to facilitate the formation of mixed teams of humans and robots that could perform complex tasks in the real world. We developed a complete end-to-end system to meet this goal. We used a natural language based multi-modal interface to enable simple interaction for the people on the team. We used policy regulated behavior for the robots to ensure effective coordination from the robotic teammates. We also employed an advanced network infrastructure to enable robust and reliable communications among team members.

Jones, D. G., Bolstad, C. A., Riley, J. M., Endsley, M. R., & Shattuck, L. G. (2003). Situation Awareness Requirements for the Future Objective Force. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures

Summary abstract:
This paper demonstrates how a Goal Directed Task Analysis (GDTA) can be used to provide insight into potential allocations of staff functions within the Objective Force Units of Action. The GDTA is a methodology that delineates the goals, decisions, and SA requirements essential for achieving a particular objective. In evaluating the responsibilities assigned to different components of a proposed command structure, the GDTA can provide support for three types of assessments: (1) an assessment of essential information requirements, (2) an assessment of likely cognitive workload associated with the proposed structure, and (3) an assessment of potential problems and/or benefits associated with a particular allocation of responsibilities. This type of assessment will highlight areas where soldiers' information needs are not being adequately met, where particular staff function allocations are overly demanding on the soldiers' cognitive resources, and where particular combinations of responsibilities within and across cells can create unexpected consequences that negatively impact the soldiers ability to successfully complete their mission.

Jones, D. G., Quoetone, E. M., Ferree, J. T., Magsig, M. A., & Bunting, W. F. (2003). An Intial Investigation into the Cognitive Processes Undelying Mental Projection. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society Conference. Denver, CO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The objective of this study is to gain insight into the cognitive mechanisms that enable a person to project how a system or environment will change over time. Two potential mechanisms for mental projection are examined: (1) mental simulation (performing a mental play by play) and (2) pattern matching (identifying critical features of the situation and matching those with previous experience). A study was performed in cooperation with the National Weather Service Warning Decision Training Branch in which 28 severe weather warning forecasters participated in an interval-based simulation. At three decision points in this simulation, participants were asked to assess the threat level for tornado, wind, hail, and flash flood and to delineate their rationale for each assessment. Results are presented that support the existence of pattern matching and mental simulation strategies, that suggest different strategies may be effective in different situations, and that indicate forecasters utilize both strategies.

Jones, L. A., Nakamura, M., & Lockyer, B. (2004). Development of a Tactile Vest. In In Proceedings of IEEE Computer Society 12th International Symposium on Haptic Interfaces for Virtual Environments and Teleoperator Systems. pp. 82-89.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This research is focused on the development of a torsobased haptic display that can be used to present navigational cues to a human operator. The requirements for this display are that it can be worn on a mobile operator, is light weight and robust. Two tactile vests are being developed to meet these objectives, one based on small electric motors and the other on contractile shapememory alloy (SMA) fibers. Four electromechanical actuators were evaluated for use in the vest and a small vibration motor was selected for the initial prototype. A 3x3 array was fabricated for psychophysical testing and positioned on the lower back. High accuracy in perceiving the direction of tactor activation was achieved by all subjects in this task. A tactor array based on SMA actuators was fabricated and tested and results indicate that this low-bandwidth device can generate tactile inputs on the torso that are perceptible.

Jones, L. A., & Sarter, N. (2008). Tactile Displays: Guidance for Their Design and Application. Human Factors, 50, 90-111.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
This article provides an overview of tactile displays. Its goal is to assist human factors practitioners in deciding when and how to employ the sense of touch for the purpose of information representation. The article also identifies important research needs in this area. Background: First attempts to utilize the sense of touch as a medium for communication date back to the late 1950s. For the next 35 years progress in this area was relatively slow, but recent years have seen a surge in the interest and development of tactile displays and the integration of tactile signals in multimodal interfaces. Athorough understanding of the properties of this sensory channel and its interaction with other modalities is needed to ensure the effective and robust use of tactile displays. Methods: First, an overview of vibrotactile perception is provided. Next, the design of tactile displays is discussed with respect to available technologies. The potential benefit of including tactile cues in multimodal interfaces is discussed. Finally, research needs in the area of tactile information presentation are highlighted. Results: This review provides human factors researchers and interface designers with the requisite knowledge for creating effective tactile interfaces. It describes both potential benefits and limitations of this approach to information presentation. Conclusion: The sense of touch represents a promising means of supporting communication and coordination in human-human and human-machine systems. Application: Tactile interfaces can support numerous functions, including spatial orientation and guidance, attention management, and sensory substitution, in a wide range of domains.

Jones, L. A. (2009). Chapter 8. Communication Via the Skin: The Challenge of Tactile Displays. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section II. Presenting Battlefield Information to Warfighters: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
Tactile communication systems represent a promising technology that can be used to present information to soldiers in a variety of contexts by utilizing a relativelyunderused sensory channel to convey information that is both private and discreet. Applications of this technology include delivering vibrotactile cues to soldiers to assist in navigation or threat location in the battlefield, providing tactile feedback to increase situational awareness in virtual environments used for training, and employing tactile cues to enhance the representation of information in multi-sensory displays used for planning and decision making. The opportunity to use the sense of touch in these diverse application domains arose as a result of tactile display technologies becoming more sophisticated due to the reduced power requirements of actuators used in the displays, and the option of wireless communication for mobile users. This in turn made the displays less intrusive and thus more acceptable to users.

Tactile displays have achieved success as communication systems in a variety of contexts in which it has been shown that vibrotactile cues delivered to the skin can provide spatial information about the environment to pilots, or alert the operator of a vehicle of an impending collision. The displays are typically composed of a matrix of electromechanical actuators (known as tactors) that are mounted in a vest or waistband and are sequentially activated to provide information about a person's spatial orientation or the position or movement of a vehicle. In most of these applications, the factors are activated at a fixed frequency and amplitude and the number and location of the tactors simultaneously active is used to convey information. Tactile displays have also been employed in environments in which the visual and auditory communication channels are heavily taxed or in which visual displays are inappropriate because the operator is involved in other activities that require attention. In these latter situations, the sense of touch provides a communication channel that is direct salient, and private.

The goal of the research conducted for the Advanced Decision Architectures Collaborative Technology Alliance (CTA) was to design and build wireless-controlled wearable tactile displays that could be used to evaluate the contexts and conditions in which tactile communication facilitated soldier performance in the battlefield, in vehicle or robot control, and in information exchange during planning for future combat missions. The domains in which it was envisaged that the displays would be used were those that required that the hands were free for other activities (e.g. holding a weapon, driving a vehicle). The display was therefore designed so that it could be worn on the arms, legs, or torso. The research at MIT focused on five issues: Can tactile signals be used to provide spatial cues about the environment that are accurately localized? How does the location and configuration of the tactile display influence the ability of the user to identify tactile patterns? What is the maximum size of a tactile vocabulary that could be used for communication? Which characteristics of vibrotactile signals are optimal for generating a tactile vocabulary? Can a set of Army Hand and Arm Signals be translated into tactile signals that are accurately identified when the user is involved in concurrent tasks? Within this framework, a series of laboratory and field studies was conducted.

The tactile displays fabricated at MIT were made available to other partners in the CTA and assistance was provided to help partners conduct experiments. Studies conducted at ARL that have used the MIT tactile display include those that have done the following: investigated the efficacy oftactile and multimodal alerts on decision making by Army Platoon Leaders; analyzed the effectiveness of tactile cues in target search and localization tasks and when controlling robotic swarms; evaluated Soldiers' abilities to interpret and respond to tactile cues while they navigated an Individual Movement Techniques (IMT) course; and measured the effects of tactile cues on target acquisition and workload of Commanders and Gunners and determined the detectability of vibrotactile cues while combat assault maneuvers were being performed. The MIT tactile displays have also been incorporated into multi-modal platforms developed by the University of Michigan, ArtisTech in the CTA test bed, and Alion MA&D for a robotics control

environment. Finally, a comprehensive review of tactile displays was written in collaboration with Nadine Sarter at the University of Michigan.

Jones, L. A., & Ho, H.-N. (2008). Warm or Cool, Large or Small? The Challenge of Thermal Displays. IEEE Transactions on Haptics, 1, 53-70.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Evaluation/methodology, haptic i/o, human information processing, user interfaces.

Summary abstract:
Thermal displays have been developed to present thermal cues to the hand to facilitate object recognition in virtual environments or in teleoperated robotic systems. This review focuses on this application domain of thermal displays and considers the models developed to simulate the thermal interaction between an object and the hand as they make contact. An overview of thermal perception and the mechanisms underlying the processing of thermal information is provided to give a framework for analyzing the design of thermal displays. The models developed to simulate thermal feedback are examined together with a description of the implementation of these models in thermal displays. The domains in which thermal displays have been used are described; this includes the simulation of material properties, the recreation of large-scale thermal effects in virtual environments, the encoding of abstract concepts, and the use of thermal feedback in interactive art. The review concludes by considering the advantages and challenges associated with using thermal displays in these diverse areas.

Jones, L. A., Kunkel, J., & Piateski, E. (2009). Vibrotactile Pattern Recognition on the Arm and Back. Perception, 38, 52-68.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
A series of experiments was conducted to evaluate the effectiveness with which a tactile display mounted on either the forearm or the back can be used to communicate simple instructions and commands. In the first two sets of experiments, participants identified a vibrotactile pattern using a visual template that represented the pattern of activation. For the patterns displayed on the forearm, accuracy depended on the specific set of patterns presented and ranged from 30% to 96% correct for the individual patterns. In a second series of experiments, seven hand-and-arm signals that are used to communicate in military contexts were converted into tactile representations that were displayed on the back. These were identified accurately (98% correct) and, when only the picture of the hand signal was available, participants achieved a recognition rate of 75% correct. A further study with these seven patterns indicated that participants were still able to identify the patterns accurately (92% correct) when they were engaged in a concurrent physical or cognitive task. The results indicate the importance of evaluating tactile communication in the context of the specific patterns or messages that will be conveyed, and that with the judicious selection of tactile patterns both the arm and back provide a functional substrate for tactile communication.

Jones, L. A., Lockyer, B., & Piateski, E. (2006). Tactile Display and Vibrotactile Recognition on the Torso. Advanced Robotics, 20(12), 1359–1374.

Key Words:
ADA CTA

Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Tactile display; haptics; touch; torso display.

Summary abstract:
A wirelessly controlled tactile display has been designed, fabricated and tested for use as a navigation aid. The display comprises a 4 × 4 array of vibrating motors that is mounted on a waist band and stimulates the skin across the lower back. Three types of electromechanical actuators were evaluated for use in the display; based on their mechanical performance and power requirements, two of these motors were then used to fabricate tactile displays. The performance of the displays and the wireless tactile control units was assessed experimentally by having subjects identify which of eight possible vibrotactile patterns was presented to the lower back. The results indicated that subjects could recognize the vibrotactile patterns with almost perfect accuracy and that there was no difference between the two types of motor used for the displays. Moreover, the ability to recognize the pattern of vibrotactile stimulation was superior on the back as compared to the forearm. A further experiment confirmed that the tactile display can be used as a navigation aid outdoors and that the vibrotactile patterns presented can be interpreted as directional or instructional cues with almost perfect accuracy

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Jones, L. A., & Nakamura, M. (2003). Haptic Displays: The Tactile Vest. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making

Summary abstract:
This research is focused on the development of a torso based haptic display that can be used to present information about orientation, direction of movement, or threat location to a soldier in the battlefield. The requirements for this display are that it can be worn on a mobile operator, has high force generating capabilities, is light weight and robust. A tactile vest based on contractile shape-memory alloy fibers is being developed to meet these objectives, and to make use of an underutilized sensory channel, while leaving the hands free for other tasks. Experiments conducted with nickel-titanium fibers in a prototype display in which a pin of non-conducting material is displaced as the fiber contracts indicate that the forces and displacements produced by these fibers greatly exceed the sensitivity thresholds of the human torso. An array of these fibers and pins has been designed and is now being built to test optimal spacing and stimulation requirements for human use.

Jones, L. A., & Ray, K. (2009). Localization and Pattern Recognition with Tactile Displays. In In Proceedings of IEEE Proceedings of the Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems, 33-39.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
CR Categories: G.3 [Mathematics of Computing]: Probability and Statistics – Experimental Design; H1.2 [Model and Principles]: User/Machine System; H.5.2 [Information Interfaces and Presentation]: User Interfaces – Theory and methods; Usercentered design
Keywords: tactile display, touch, torso, localization, tactons

Summary abstract:
A set of four experiments was conducted to evaluate tactile localization and tactile pattern recognition on the torso. A onedimensional eight-tactor display and a two-dimensional 16-tactor display were used to present tactile cues to the waist and back respectively. The results from the spatial localization experiments indicated that a display with eight tactors mounted circumferentially around the waist can provide tactile cues that are perceived very accurately in terms of the location of stimulation. In contrast, the 16-tactor array on the back was found to be inadequate to support precise spatial mapping, but an array with fewer elements could provide such spatial cues. The second set of

experiments evaluated tactile pattern recognition around the waist and on the back with the objective of determining what types of tactile stimuli could be useful for creating tactons. The tactile display used in these experiments stimulated the skin at a fixed frequency and amplitude and varied the number and location of tactors simultaneously active to convey information. For both the waist and back, tactile patterns were identified with high accuracy, 99% and 95% correct response rate respectively. These findings suggest that simple navigational and instructional commands can be presented tactually on the torso.

Jones, R. E. T., Connors, E. S., & Endsley, M. R. (2009). Incorporating the Human Analyst into the Data Fusion Process by Modeling Situation Awareness Using Fuzzy Cognitive Maps. In In Proceedings of 12th International Conference on Information Fusion. Seattle, WA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Situation awareness, fuzzy cognitive maps, high level fusion, and human cognitive processes.

Summary abstract:
Current data fusion models lack the capability of fully supporting the cognitive processes of the human analyst. The data fusion community has expressed a need to better incorporate users within their models. The purpose of this paper is to describe how to use fuzzy logic to develop a data fusion model that supports situation awareness (SA). Developing this model based on the formal representation of the analyst provided by the Goal- Directed Task Analysis (GDTA) methodology advances current data fusion models because it provides valuable insight on how to effectively support human cognition within the data fusion process.

Jones, R. E. T., Connors, E. S., Mossey, M. E., Hyatt, J. R., Hansen, N. J., & Endsley, M. R. (2009). Modeling Situation Awareness for Army Infantry Platoon Leaders Using Fuzzy Cognitive Mapping Techniques. In In Proceedings of 19th Behavior Representation in Modeling and Simulation (BRIMS).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Situation Awareness, Fuzzy Cognitive Maps, Army Infantry Platoon, METT-TC, Modeling and Simulation

Summary abstract:
This paper describes work on the development of an actionable model of situation awareness for Army infantry platoon leaders using fuzzy cognitive mapping techniques. Developing this model based on the formal representation of the platoon leader provided by the Goal-Directed Task Analysis (GDTA) methodology advances current cognitive models because it provides valuable insight on how to effectively support human cognition within the decision-making process. We describe the modeling design approach and discuss validating the model using the VBS2 simulation environment.

Josephson, J. R. (2008). Abductive Inferencing for Integrating Information from Human and Robotic Sources. In In Proceedings of Fusion 2008 Conference, Cologne, Germany.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
abductive inference, hard source, soft source,
level-1 fusion, level-3 fusion, credibility, veracity.

Summary abstract:
Abductive inference (best-explanation reasoning) is a useful conceptual framework for analyzing and implementing the inferencing needed to integrate information from human and robotic sources. Inferencing proceeds from reports, to explanations for these reports, given in terms of hypothesized real-world entities and the processes by which the entities lead to the reports.

Reports from humans and robotic sources are subject to different kinds of corruption, so they require different treatment as sources of evidence. The best explanation for a certain report might be that it presents a reliable statement that results from a chain of causality from the events reported, to their effects on human or robotic senses, and from there through transduction, processing, and reporting. Confidence in this explanation will be undercut by evidence supporting a rival explanation, such as one involving error or intended deception.

Josephson, J. R., Chandrasekaran, B., & Carroll, M. (2003). Toward a Generic Architecture for Multisource Information Fusion. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures

Summary abstract:
This paper sketches a design for software for building, composing, and maintaining information fusion application software. It is intended to support a broad range of information fusion applications that vary with respect to types of information sources (imaging sensors, human reports, etc.) and with respect to operational demands (e.g., timeliness, reliability, availability of human attention). The design relies on abductive inference, compositional modeling, model-based prediction, anomaly-driven processing, and need-driven processing. Some main components of the design have previously been demonstrated in prototype systems that have shown good performance.

Josephson, J. R., Eckroth, J., & Miller, T. N. (2009). Estimation of Adversarial Social Networks by Fusion of Information from a Wide Range of Sources. In In Proceedings of 12th International Conference on Information Fusion, Fusion 2009. Seattle, WA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings Information fusion, soft information, social networks, biometrics, asymmetric warfare, urban operations

Summary abstract:
A data structure is described that serves to define a target structure for estimating social networks. It represents who knows whom, the strength and polarity of associations, and levels of confidence that linked individuals are actually personally acquainted. This network, which represents social structure, is embedded in a more inclusive network structure that also represents vehicles, places and organizations. This broader structure can be used to accumulate information to enable automated inferencing to assist human processing in estimating the social network of interest. How portions of this inferencing can be done is briefly described, and a scenario is given that illustrates the use of this kind of fused information to make a decision. We also review a range of hard and soft information sources with emerging value for estimating adversarial social networks, and describe how these sources can be used for the purpose.

Josephson, J. R., Sobieski, A., & Chandrasekaran, B. (2003). Detection of Social Order: Finding Dense and Isolated Groups Using Message Traffic. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making

Summary abstract:
This paper reports on the discovery of what appears so far to be a very effective computational strategy for finding suspects belonging to relatively dense and/or isolated groups. In experiments so far, this “S2B2-S1B1” filtering strategy has been both sensitive (does not miss groups) and selective (does not give many false positives). We

describe analysis and experiments to understand why this strategy works as well as it does, and to discover its limits. This strategy might be integrated into multisource systems for finding and analyzing enemy command and control systems, and finding their points of vulnerability.

Juarez, O., & Gonzalez, C. (2003). Masa: Meta-Architecture for Situation Awareness. In In Proceedings of Behavior Representation in Modeling and Simulation Conference. Scottsdale, AZ.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
MASA:
• A Meta-Architecture to model SA in different domains
• Helps modularize the knowledge and the system functionality to represent SA
• First initial development: Models of Situation Awareness in complex battle situations.

Juarez-Espinosa, O., & Gonzalez, C. (2003). Situation Awareness of Commanders: A Cognitive Model. In In Proceedings of Conference on Behavior Representation in Modeling and Simulation. Arlington, VA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Situation Awareness, Cognitive Model

Summary abstract:
This paper discusses a computational model of situation awareness (SA) for military command and control in complex battle situations. Cognitive modeling is a research method that does not forgive vagueness. How do military commanders create awareness in a highly complex and uncertain world? The model described in this paper simulates computationally some of the cognitive operations performed by commanders during the evaluation of a complex battle situation.
Although the set of cognitive processes that support SA are still not well understood, we have hypothesized a metaarchitecture involving: information gathering, assessment, and alternative generation. The cognitive model reported here paves the road towards a more complete and valid representation. The model was implemented using ACT-R, a cognitive architecture, and tested with scenarios running in OTB, a simulation tool for war scenarios.

Juarez-Espinosa, O., & Gonzlaez, C. (2003). Using Petri Nets to Analyze Cognitive Multitasking Domains. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003 (pp. 175-177). College Park, MD: U.S. Army Research Laboratory.

Key Words:
Human Performance

Summary abstract:
This paper describes the use of Petri nets (PN) to perform analysis of concurrency, synchronization, and conflict in multitasking domains. Those analyses precede the design and implementation of cognitive models. Petri nets (PN) are useful tools to model multitasking and attention sharing. To demonstrate the usefulness of this tool in the process of designing a cognitive mode, we present an example that involves four tasks. A prototype to analyze two tasks that share the visual resources was implemented using a PN tool. The manipulation of parameters for delay and priorities in the transitions provided us with good information about this task which enabled us to design and implement the cognitive model.

Jung, H., Bradshaw, J. M., Kulkarni, S., Breedy, M., Bunch, L., Paul Feltovich, Jeffers, R., Johnson, M., Lott, J., Suri, N., Taysom, W., Tonti, G., & Uszok, A. (2004). An Ontology-Based Representation for Policy-Governed

Adjustable Autonomy. In In Proceedings of American Association for Artificial Intelligence (AAAI) Spring Symposium. Stanford, CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Policies are a means to dynamically regulate the behavior of system components without changing code nor requiring the cooperation of the components being governed. By changing policies, a system can be continuously adjusted to accommodate variations in externally imposed constraints and environmental conditions. KAoS policy and domain services rely on an OWL ontology of the computational environment, application context, and the policies themselves that enables runtime extensibility and adaptability of the system, as well as the ability to analyze policies relating to entities described at different levels of abstraction. Besides the currently implemented conflict detection and resolution methods, we are developing an approach to determine how and when to make policy changes based on adjustable autonomy considerations. This approach relies heavily on the information contained in the KAoS Policy Ontologies.

Kaber, D. B., & Endsley, M. R. (2004). The Effects of Level of Automation and Adaptive Automation on Human Performance, Situation Awareness and Workload in a Dynamic Control Task. Theoretical Issues in Ergonomic Science, 5(2), 113-153.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Level of automation (LOA); adaptive automation (AA); human-centred automation;
situation awareness; mental workload; embedded-secondary task.

Summary abstract:
This paper extends previous research on two approaches to human-centred automation: (1) intermediate levels of automation (LOAs) for maintaining operator involvement in complex systems control and facilitating situation awareness; and (2) adaptive automation (AA) for managing operator workload through dynamic control allocations between the human and machine over time. Some empirical research has been conducted to examine LOA and AA independently, with the objective of detailing a theory of human-centred automation. Unfortunately, no previous work has studied the interaction of these two approaches, nor has any research attempted to systematically determine which LOAs should be used in adaptive systems and how certain types of dynamic function allocations should be scheduled over time. The present research briefly reviews the theory of humancentred automation and LOA and AA approaches. Building on this background, an initial study was presented that attempts to address the conjuncture of these two approaches to human-centred automation. An experiment was conducted in which a dual-task scenario was used to assess the performance, SA and workload effects of low, intermediate and high LOAs, which were dynamically allocated (as part of an AA strategy) during manual system control for various cycle times comprising 20, 40 and 60% of task time. The LOA and automation allocation cycle time (AACT) combinations were compared to completely manual control and fully automated control of a dynamic control task performed in conjunction with an embedded secondary monitoring task. Results revealed LOA to be the driving factor in determining primary task performance and SA. Low-level automation produced superior performance and intermediate LOAs facilitated higher SA, but this was not associated with improved performance or reduced workload. The AACT was the driving factor in perceptions of primary task workload and secondary task performance. When a greater percentage of primary task time was automated, operator perceptual resources were freed-up and monitoring performance on the secondary task improved. Longer automation cycle times than have previously been studied may have benefits for overall human-machine system performance. The combined effect of LOA and AA on all measures did not appear to be 'additive' in nature. That is, the LOA producing the best performance (low level automation) did not do so at the AACT, which produced superior performance (maximum cycle time). In general, the results are supportive of intermediate LOAs and AA as approaches to human-centred automation, but each appears to provide different

benefits to human-machine system performance. This work provides additional information for a developing theory of human-centred automation.

Kamali, K., Fan, X., & Yen, J. (2006). Multiparty Proactive Communication: A Perspective for Evolving Shared Mental Models. In In Proceedings of the Twenty First National Conference on Artificial Intelligence (AAAI-06), Boston, MA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Helping behavior in effective teams is enabled by some overlapping “shared mental models” that are developed and maintained by members of the team. In this paper, we take the perspective that multiparty “proactive” communication is critical for establishing and maintaining such a shared mental model among teammates, which is the basis for agents to offer proactive help and to achieve coherent teamwork. We first provide formal semantics for multiparty proactive performatives within a team setting. We then examine how such performatives result in updates to mental model of teammates, and how such updates can trigger helpful behaviors from other teammates.

Kaste, R., Heilman, E., & Hoffman, R. (2007). Concept Map Value Propagation for Tactical Intelligence. In In Proceedings of Twelfth International Command and Control Research and Technology Symposium (12th ICCRTS), 19-21
June 2007, Newport, RI. DTIC ADA481481.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Fields and Groups:
150400 - Military Intelligence
230200 - Human Factors Engineering & Man Machine System
Descriptors:
(U) *MAN MACHINE SYSTEMS, *TACTICAL INTELLIGENCE, PROPAGATION, SYMPOSIA, NODES, SOFTWARE TOOLS, KNOWLEDGE MANAGEMENT, SITUATIONAL AWARENESS, DATA LINKS, COMMAND AND CONTROL SYSTEMS, MAPS
Identifiers:
(U) *CMAPS(CONCEPT MAPS), INFERENCE NETWORKS

Summary abstract:
Command and control analysts increasingly apply traditionally unassociated concepts to situation understanding. Techniques are needed to tailor knowledge acquisition resource allocation according to probable value of information, both inferring an answer to a question using knowledge at hand and quickening intelligence efforts to fill in gaps. Concept Maps ("Cmaps") are a form of meaningful diagram that represents concepts as nodes, linked by specified relationships. This paper discusses research into methods for negotiating and updating Cmaps by accounting for both nodal data and links. Cmaps provide the flexibility to represent at a meaningful level contemporary tactical knowledge not lending itself to conventional data structures. In some senses Cmapping generalizes the notion of an inference network, a set of propositions organized with rules directing information propagation and combining antecedents to update consequents. We are attempting to develop a mathematical system for organized navigation of a Cmap, driven by expected variability in the value of a datum and cost to get a new value. We use the CmapTools software developed with DoD support at the Institute of Human and Machine Cognition as a structural basis for creating and assessing tactical Cmaps. The paper sets forth Cmap construction, analytical philosophy, and methodology development.

Kaste, R., O'May, J., Heilman, E., Josephson, J. R., & Chandrasekaran, B. (2003). From Simulation to Insights: Experiments in the Use of a Multi-Criterial Viewer to Develop Understanding of the Coa Space. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective

Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures

Summary abstract:
Building on advances in modeling and simulation, the U.S. Army Research Laboratory (ARL) has developed a capability for simulating detailed Courses of Action (COAs). The Ohio State University (OSU) has developed a multi-criterial decision technology known as the Seeker-Filter-Viewer. In this paper, we report on initial results of a collaborative effort between researchers at ARL and OSU in experimenting with the decision tool for mining ARL combat simulation data to gain battle-planning insights. The capability of simulating detailed COAs opens up possibilities of mining collected data for insights. Decision support systems could assist commanders in examining simulation data for relationships between COA structure and various battle objectives. The synergy of data mining tools, high performance computing, and advanced high-resolution combat simulation has potential to lead battle planners to new insights for imminent combat, translating to improved battlefield assessments and expedient modification of COAs.

Kiekel, P. A., Cooke, N. J., Foltz, P. W., Gorman, J. C., & Martin, M. J. (2002). Some Promising Results of Communication-Based Automatic Measures of Team Cognition. In In Proceedings of 46th Annual Meeting of the Human Factors and Ergonomics Society. Baltimore, MD. (pp. 298-302).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Some have argued that the most appropriate measure of team cognition is a holistic measure directed at the entire team. In particular, communication data are useful for measuring team cognition because of the holistic nature of the data, and because of the connection between communication and declarative cognition. In order to circumvent the logistic difficulties of communication data, the present paper proposes several relatively automatic methods of analysis. Four data types are identified, with low-level physical data vs. content data being one dimension, and sequential vs. static data being the other. Methods addressing all four of these data types are proposed, with the exception of static physical data. Latent Semantic Analysis is an automatic method used to assess content, either statically or sequentially. PRONET is useful to address either physical or content-based sequential data, and we propose CHUMS to address sequential physical data. The usefulness of each method to predict team performance data is assessed.

Kiekel, P. A., Cooke, N. J., Foltz, P. W., & Shope, S. M. (2001). Automating Measurement of Team Cognition through Analysis of Communication Data. In M.J. Smith, G. Salvendy, D. Harris, & R.J. Koubek (Eds.), Usability Evaluation and Interface Design. Pp. 1382 - 1386. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
In this paper we propose a general methodological approach for semi-automntically assessing team cognition using communicntion data. The approach rests on four premises: I) analyzing conununication data is a means of assessing team cognition. 2) both substantive content and physical quantity measures of communication are needed. 3) sequential flow methods are especially helpful to effectively make use of communication data, and 4) analysis of both data types can be automated with contemporary tools , both statically and sequentially. We begin by illust rating the first three points. Next, we briefly review commonly employed methods of communication analysis. and

note the difficulties of analyzing such data. We then suggest that appropriate automatic methods for analyzing communication data are becoming increasingly available, and we give some examples of our approach. Finally, we conclude by discussing the implications of Ihis approach, especially for team training and groupware design.

Klein, G. (2003). Chapter 12. Executive Intent: How to Communicate Your Intuitions. In G. Klein (Ed.), Intuition at Work. New York: Doubleday.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
One of the difficulties in using intuitive decision making is that you may struggle to express exactly what your intuition is telling you. It isn't enough to make great decisions if you can't get them implemented. We run into this problem on both ends: when we try to communicate our intent to our subordinates and when we struggle to interpret the intent expressed by our bosses.
We need to find ways to communicate our intentions clearly to our subordinates. When they don't understand the reasons behind our instructions, they're ill-equipped to respond to unexpected problems or questions. That's what made it hard to figure out how to respond to George in the second phase of the decision game.
And when we are receiving directions and intentions from someone else, such as Jennifer in the decision game above, we have to reach beyond the words to determine what the person wants.

Klein, G., & Armstrong, A. A. (2005). Chapter 35. Critical Decision Method. In N. Stanton, A. Hedge, K. Brookhuis, E. Salas, & H. Hendrick (Eds.), Handbook of Human Factors and Ergonomics Methods (pp. 1-8). London: CRC Press.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section
Critical Decision Method
Background and Scenario
• Observation of Scenario
• Observations of Human–System
Interactions
• Postobservation Interviews
Adapting Critical Decision Method to Address Critical
Needs
• Within-Method Adaptations
• Cross-Method
Adaptations
Standards, Regulations, and Adaptation
Identifying an Incident
• Creating a Detailed Timeline
• Deepening on Decision Points
• Probing with “What-If ”

Summary abstract:
Background and Application
The naturalistic study of expert decision making requires an in-depth analysis of complex cognitive tasks. It involves the exploration of the use of perceptual cues, the development of expert knowledge, and the evolution of expert

strategies. This type of exploration is most effective when experts are studied in the context of their complex environments. Cognitive Task Analysis (CTA) methods for eliciting and analyzing the aspects of expertise needed to perform complex tasks have been evolving over the past two decades.
CTA methods must be highly adaptable for two reasons. First, the data collection conditions can vary from one project to the next, and therefore the methods have to be flexible. Second, CTA methods are often used to make new discoveries, which mean that the phenomena of interest are not well known at the outset of the research. Consequently, the CTA methods being used must be adjustable to take advantage of what has been learned so that they can better focus on the critical issues.
The method was developed more than 15 years ago (Klein et al., 1986) and continues to be useful for conducting naturalistic decision-making research. We have codified the procedures for conducting Critical Decision Method (CDM) projects, but at the same time we, and others in our field, continue to learn how to adapt the CDM by changing the way it is executed and by synthesizing it with complementary data-collection tools and approaches.
Procedure: Overview of the Critical Decision Method
One approach to cognitive task analysis is the CDM (Klein et al., 1989; Hoffman et al., 1998). The CDM was developed as an extension of the critical incident technique (CIT) (Flanagan, 1954) and uses indepth interviews to gather retrospective accounts of challenging incidents. The CDM is a semistructured interviewing technique for investigating phenomena that rely on subtle cues, knowledge, goals, expectancies, and expert strategies.
The CDM does not use a strict protocol of interview questions. It is structured by a set of interview phases or "sweeps" that examine the incident in successively greater detail. A typical CDM session requires approximately 2 hours to move through each of the four interview sweeps:
1. Identify a complex incident that has the potential to elicit discoveries about cognitive phenomena.
2. Create a detailed incident timeline that shows the sequence of events.
3. Deepen strategies for managing the decision points embedded in the timeline.
4. Probe with what-if queries to elicit potential expert/novice differences.

Klein, G., Feltovich, P. J., Bradshaw, J. M., & Woods, D. D. (2004). Common Ground and Coordination in Joint Activity. In W.B. Rouse and K.R. Boff (Eds.), Organizational Simulation. New York: John Wiley & Sons, Inc.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Generalizing the concepts of joint activity developed by Clark (1996), we describe key aspects of team coordination. Joint activity depends on interpredictability of the participants' attitudes and actions. Such interpredictability is based on common ground—pertinent knowledge, beliefs and assumptions that are shared among the involved parties. Joint activity assumes a basic compact, which is an agreement (often tacit) to facilitate coordination and prevent its breakdown. One aspect of the Basic Compact is the commitment to some degree of aligning multiple goals. A second aspect is that all parties are expected to bear their portion of the responsibility to establish and sustain common ground and to repair it as needed.
We apply our understanding of these features of joint activity to account for issues in the design of automation. Research in software and robotic agents seeks to understand and satisfy requirements for the basic aspects of joint activity. Given the widespread demand for increasing the effectiveness of team play for complex systems that work closely and collaboratively with people, observed shortfalls in these current research efforts are ripe for further exploration and study.

Klein, G., & Hoffman, R. R. (2008). Chapter 4. Macrocognition, Mental Models, and Cognitive Task Analysis Methodology. In J.M. Schraagen, L.G. Militello, T. Ormerod, & R. Lipshitz (Eds.), Naturalistic Decision Making and Macrocognition (pp. 57-80). Aldershot, England: Ashgate Publishing, Inc.

Key Words:
ADA CTA

Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
In one view of macro cognition (Klein et ai., 2003), the "primary functions" are things that domain practitioners say they need to accomplish: replanning, sensemaking, decision making, and so on. The "supporting processes" are cognitive capacities that make possible the achievement of the primaries. Mental modeling is such a supporting process, especially critical for sensemaking (Klein et aI., 2006). This chapter is an exploration of some methods for gathering data, representing, and studying mental models. (In this chapter, we do not review methods of knowledge elicitation, broadly conceived. Reviews have been provided by Cooke (1992, 1994), Crandall, Klein, and Hoffman (2006), Hoffman and Lintem (2006), Hoffman et al. (1995), and Olson and Reuter (1987).)
Our purpose in this chapter is fairly immediate and practical: To discuss methods and methods for studying mental models. We discuss tried-and-true methods, but we also present some ideas about new methods, with an invitation for researchers to apply and evaluate them. This is a practitioner's account, that is, a description of a battery of techniques that researchers have developed for dealing with the problems associated with eliciting and refining meaningful and usable accounts of expert cognition. Our stance is "practitioner confessional" rather than a dogmatic "this is how it should be." This chapter is basically an invitation to naturalistic empirical inquiry: If one were conducting cognitive task analysis (eTA) on experienced domain practitioners, for purposes such as cognitive systems engineering, what sorts of methods might be used to reveal mental models?
First, however, we do need to deal with some philosophical issues. Any treatment of mental models cOLdd go into great length about issues of scientific meaning, validity, relation to phenomenology, and so on, and could rehash a considerable literature on the scientific status of mental models. With this in mind, we take pains to be succinct.

Klein, G., Moon, B., & Hoffman, R. R. (2006). Making Sense of Sensemaking 1: Alternative Perspectives. IEEE Intelligent Systems, 22-25.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
A man was worried about his 72-year-old father, who had just had a pacemaker implanted. The man believed that his father’s condition was serious, despite reassurances from the hospital staff. The man’s father had shortness of breath, cardiac arrhythmia, mild congestive heart failure, an enlarged heart, water retention, mild high blood pressure, mild emphysema, and a heart valve replacement 10 years earlier. The combination of all these symptoms and problems seemed ominous. The man coaxed a physician to explain what was going on.
The physician said that the heart valve replacement was irrelevant. Basically, the father had a slightly enlarged heart. That wasn’t a big problem except that the area of enlargement had stretched some of the nerves that controlled heart rate; this caused the cardiac arrhythmia. The arrhythmia, in turn, meant that the father’s heart was less efficient at maintaining fluid levels, which is often a problem of aging. So, the fluid buildup resulted in mild congestive heart failure and shortness of breath. The mild emphysema didn’t help. And that’s why they installed the pacemaker. With that simple story, the various data elements fit together in a coherent causal scheme, satisfying the man that this was a treatable problem rather than a cascading breakdown of health.
This story is one of many that researchers use to illustrate the phenomenon of sensemaking. Although we can trace this notion to the early 1980s,1 it has emerged since the 1990s as a subject for organizational research,2–4 educational research,5 and symposia on decision making.6 Sensemaking has become an umbrella term for efforts at building intelligent systems—for example, the research on data fusion and adaptive interfaces.7,8 Research requests are frequently issued for intelligent systems that will
• automatically fuse massive data into succinct meanings,
• process meaning in contextually relative ways,
• enable humans to achieve insights,
• automatically infer the hypotheses that the human is considering,

• enable people to access others' intuitions, and
• present information in relevant ways and defined in terms of some magically derived model of the human subconscious or its storehouse of tacit knowledge.

These envisioned capabilities appear to be good things to have, and the call for research on such capabilities might serve to throw down a gauntlet and thereby push the envelope of intelligent systems. But we see in various funding opportunities and program descriptions little actual relationship to the notion of sensemaking, especially to empiricalresearch findings from the field of naturalistic decision making. This essay examines sensemaking from various perspectives to see if we can separate the things that are doable from the things that seem more like pie-in-the-sky.

Klein, G., Moon, B., & Hoffman, R. R. (2007). Making Sense of Sensemaking 2: A Macrocognitive Model. IEEE Intelligent Systems, 22-26.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
In our first essay on sensemaking,1 we discussed various possible meanings of the concept and debunked some of the myths that seem current in discussions of cognitive work. The motivation for these two essays is to question whether it makes sense to envision certain kinds of intelligent sensemaking systems. None of the "verdicts" we announced in the first essay mean that intelligent technologies might not assist people in sensemaking. Indeed, intelligent technologies might help; they just won't be the sorts of technologies that people seem to seek.

Gary Klein and his colleagues have laid out a theory of sensemaking that might be useful for intelligent systems applications.2 It's a general, empirically grounded account of sensemaking that goes significantly beyond the myths and puts forward some nonobvious, testable hypotheses about the process.

When people try to make sense of events, they begin with some perspective, viewpoint, or framework—however minimal. For now, let's use a metaphor and call this a frame. We can express frames in various meaningful forms, including stories, maps, organizational diagrams, or scripts, and can use them in subsequent and parallel processes. Even though frames define what count as data, they themselves actually shape the data (for example, a house fire will be perceived differently by the homeowner, the firefighters, and the arson investigators). Furthermore, frames change as we acquire data. In other words, this is a twoway street: Frames shape and define the relevant data, and data mandate that frames change in nontrivial ways.

Figure 1 shows that the basic sensemaking act is dataframe symbiosis. The figure captures a number of sensemaking activities. Sensemaking can involve elaborating the frame by adding details, and questioning the frame and doubting the explanations it provides.3 A frame functions as a hypothesis about the connections among data. One reaction to doubt is to explain away troublesome data and preserve the frame.4,5 These two aspects, elaborating the frame and preserving the frame, are part of the elaboration cycle of sensemaking (the left side of figure 1), akin to Jean Piaget's notion of assimilation.

Yet another sensemaking cycle is to reframe (see the figure's right side). Here, questioning the frame leads us to reconsider—to reject the initial frame and seek to replace it with a better one. We might compare alternative frames to determine which seems most accurate. Or we might simply be mystified by the events. The sensemaking activity here, akin to Piaget's notion of accommodation, is to find some sort of frame that plausibly links the events that are being explained.

Each of these aspects of sensemaking has its own dynamics, strategies, and requirements. Recognizing a frame and recognizing data are different from elaborating a frame that has already been adopted, and this is different from explaining away inconsistencies. Different still are the reactions to questioning a frame—choosing between alternative frames and constructing a frame where none exists.

The Data/Frame Theory posits a closed-loop transition sequence between
• mental model formation (which is backward looking and explanatory), and
• mental simulation (which is forward looking and anticipatory).

Think of the simplest transition sequence as a chain of closed loops. Each loop is triggered by a perceived subevent, leading to an effort to refine the existing mental model (backward looking) and an effort to run a new mental

simulation (forward looking). You can construct a transition sequence retrospectively to generate an explanation of how events and subevents unfolded, or prospectively to imagine how a major causal factor or a situational mix of factors might play out. For illustration, envision a transition sequence using the metaphor of billiards, where a player would anticipate how hitting one ball would lead to motion in a second, and a third, to the shot's completion.

Klein, G., Pliske, R., Crandall, B., & Woods, D. D. (2005). Problem Detection. Cognition, Technology, and Work, 7(1), 14-28.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Problem detection is the process by which people first become concerned that events may be taking an unexpected and undesirable direction that potentially requires action. Previous accounts [e.g., Cowan (Acad Manage Rev 11(4):763–776, 1986)] described problem detection as the accumulation of discrepancies until a threshold was reached. In reviewing incidents taken from a variety of natural settings, we found that discrepancy accumulation did not apply to the incidents we reviewed, because (a) cues to problems may be subtle and context-dependent, and (b) what counts as a discrepancy depends on the problem-solver's experience and the stance taken in interpreting the situation. In many cases, detecting a problem is equivalent to reconceptualizing the situation.

Klein, G., Ross, K. G., Moon, B. M., Klein, D. E., Hoffman, R. R., & Hollnagel, E. (2003). Macrocognition. IEEE Intelligent Systems, 18(3), 81-85.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
If we engineer complex cognitive systems on the basis of mistaken or inappropriate views of cognition, we can wind up designing systems that degrade performance rather than improve it. The results stemming from the application of any cognitive systems engineering methodology will be incomplete unless they include a description of the cognition that is needed to accomplish the work. The concept of macrocognition is a way of describing cognitive work as it naturally occurs.

Klein, G., Veinott, E. S., & Sieck, W. R. (2009). Chapter 18. Advancing Our Understanding of Batilefield Decision Making. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section IV. Communicating Information across the Team: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:

The process of command and control, which is central to U.S. Army operations, depends heavily on cognitive functions such as decision making. Commanders and staff members are engaged in planning and replanning, in interpreting the actions of adversaries, in re-programming resources, in making personnel assignments, and in many related activities. They have to make high stakes decisions under uncertainty and time pressure. In order to support them through training, organizational design, and decision support systems, it is essential to understand how they can use their experience to make effective decisions when faced with complex conditions.
In 1989, the Army Research Institute for Behavioral and Social Sciences sponsored the first conference on Naturalistic Decision Making (NDM, Klein, Orasanu, Calderwood, & Zsambok, 1993). The NDM framework was designed to investigate decision making under difficult conditions: vague goals, uncertainty, changing environmental features, high stakes, team and organizational constraints on action (Orasanu & Connolly, 1993). It is important to understand decision making under these kinds of conditions in order to develop effective training programs, information technology applications, and doctrine.
One ofthe best-known of the NDM accounts is the Recognition Primed Decision (RPD) model, which explains how people are able to make decisions without having to compare options (Klein, 1998; Klein, Calderwood, & Clinton-Cirocco, 1986). The RPD model posits that people are able to rely heavily on the first option they generate because their experience has been compiled as patterns. A pattern-matching process enables them to rapidly match a situation to a prototype pattern they have already compiled, which lets them focus their attention on relevant cues, determine plausible goals, form expectancies, and identify promising courses of action. Therefore, in most cases the first option they consider will be effective. They only have to generate additional options when their first option is evaluated as unacceptable. They do not even have to generate several options in order to make a comparative evaluation. The evaluation is conducted through a process of mental simulation (which De Groot, 1946/1978, termed "progressive deepening").
The RPD model has been tested. The initial research with firefighters has been extended to other domains, and the dominant finding is that the strategy described by the model is used in the great majority of situations- between 80% and 90% ofthe time. Rarely do decision makers contrast alternative options using a common set of evaluation criteria. These findings have been replicated by different research groups. Klein (1998) has provided a comprehensive account of the tests and replications of the RPD model.
By the time the Army Research Laboratory Advanced Decision Architectures (ARL ADA) program began in 2001, the NDM framework had become well established for studying decision making in field settings, and the RPD model had become widely accepted as a description of the way people actually make decisions. The ARL ADA program has been extremely valuable for moving our understanding of decision making forward. It directly resulted in advances in the RPD model, and in the extension of the NDM framework to cover additional cognitive functions and processes. This chapter describes how the ARLADA program enabled Klein Associates to make important progress. Other ARLADA contractors have also made important progress, particularly in modeling recognitiona I decision making.

Klein, G., Wiggins, S. L., & Lewis, W. R. (2003). Replanning in the Army Brigade Command Post. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003 (pp. 197-200). College Park, MD: U.S. Army Research Laboratory.

Key Words:
Human Performance

Summary abstract:
Although replanning is critical for effective operations, it has received little attention from the research community to date. Replanning presents a commander and staff with a unique set of demands and challenges. Preliminary studies of this topic have identified the kinds of disruptions that require replanning and indicated the barriers to effective replanning. The current effort intends to describe the replanning process, identify its macrocognitive requirements, and formulate requirements for replanning support systems. In preparation for this research, a number of cognitive challenges to effective replanning have been identified. The main activities of the effort are to conduct observations and Cognitive Task Analysis interviews at Army exercises involving Future Combat System and Objective Force dynamics. Several such exercises have been attended and preliminary insights are presented.

Klein, G., Woods, D. D., Bradshaw, J. M., Hoffman, R. R., & Feltovich, P. J. (2005). Ten Challenges for Making Automation a “Team Player” in Joint Human-Agent Activity IEEE Intelligent Systems(November/December), 91-95.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
We propose 10 challenges for making automation components into effective “team players” when they interact with people in significant ways. Our analysis is based on some of the principles of human-centered computing that we have developed individually and jointly over the years, and is adapted from a more comprehensive examination of common ground and coordination.

Knoll, G., Suri, N., & Bradshaw, J. M. (2002). Path-Based Security for Mobile Agents. Electronic Notes in Theoretical Computer Science (ENTCS) issue on Security of Mobile Multiagent Systems (SEMAS). Elsevier Science, 63, 54-60.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
As mobile agents are increasingly adopted in intranets, on the Internet, and on computational grids, new security concerns become increasingly important. Unlike other kinds of mobile code, such as applets, which are pulled a single time to remote systems (single-hop), mobile agents may move using their own itinerary through a series of systems (multiple-hop), potentially carrying sensitive information with them. In such scenarios, mobile agents introduce new vulnerabilities: hosts are at the mercy of malicious (or buggy) agents that may compromise the integrity of the host execution environment and agents are at the mercy of malicious hosts that are capable of examining or modifying the code or data of the agent, or presenting a false environment to the agent (as in a masquerade attack), thereby causing the agent to execute incorrectly. Widely used security measures such as cryptography, authentication, and access control do not address these kinds of problems.
A particularly dangerous form of agent tampering by a malicious host occurs in the multiple-hop scenario. In this situation, an agent that was benign (and potentially trusted) to begin with could be turned into a malicious agent. Since the agent was originally a trusted agent, a subsequent host might naively grant the agent higher privileges, which could be misused by the now malicious agent. Such an agent could cause significantly more damage to the unsuspecting host than a malicious agent that was not trusted by the host and thereby executed with greater protections.
Some solutions have been developed to address both security concerns: protecting hosts from malicious agents and protecting agents from malicious hosts. Note that it is also possible for a malicious agent to attack another agent. However, given that a malicious host has complete control over an agent’s execution environment, the points of attack available to a malicious host comprise a superset of the points of attack available to a malicious agent. Therefore, the problem of protecting an agent from a malicious agent is subsumed by the problem of protecting the agent from a malicious host.
In general, the solutions to protect hosts are successful (if the hosts applies the necessary security mechanisms when executing agents). However, the solutions to protect agents have not been successful. The goal of this effort is not to solve the problem of protecting an agent from a malicious host, but to help a host determining the appropriate trust level of a visiting agent so that a host may protect itself using the necessary security mechanisms. Section two of this paper provides a survey of existing solutions to mobile agent security. The following section briefly describes the NOMADS mobile agent environment where our proposed security solution is being implemented.

Section four presents the proposed solution for path-based security for mobile agents. Section five concludes with a summary and a discussion of future work.

Koopman, P., & Hoffman, R. R. (2004). Work-Arounds, Make-Work, and Kludges. IEEE: Intelligent Systems, pp. 70-75.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Paradigms are often defined partly in terms of what they are not, or in terms of what they are reacting against. The paradigm of human-centered computing is no exception. In response to an essay in the Jan./Feb. 2002 Human-Centered Computing column “The State of Cognitive Systems Engineering,”1 we had a lengthy discussion on the question, What is a user-hostile system? The following quote is from that essay: The road to user-hostile systems is paved with user-centered intentions on the part of the designers. Even smart, clever, well-intentioned people can build devices that are fragile and hostile, devices that force the human to adapt and build local kludges and work-arounds. Worse still, even if one is aware of this trap, one will still fall into it.
We decided that the terms kludge and work-around, and also the related concept of make-work, have yet to be clearly defined for the intelligent systems community. Human-centered systems are different from user-hostile systems as well as from systems based on a designercentered approach.2 In this essay, we try to clarify the senses of these three terms and suggest ways we might study work-arounds, make-work, and kludges as an integral part of human-computer systems—rather than as embarrassing necessities that are best swept under the computing research rug.

Kurup, U., & Chandrasekaran, B. (2006). Multi-Modal Cognitive Architectures: A Partial Solution to the Frame Problem. In In Proceedings of 2006 Cognitive Science Conference.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Multi-modal; Cognitive Architectures;
Diagrammatic Reasoning; Frame Problem

Summary abstract:
Since its definition by McCarthy in 1969, the Frame Problem (FP) has been one of the more heavily debated problems in AI. Part of the debate has been on the exact definition of what the FP really is. The computational aspect of the FP can be thought of as reasoning about what changes and what doesn’t change in a dynamic world. The “sleeping dog strategy” is considered to be a viable solution to this aspect of the FP. We intend to show that this strategy has a weakness that can be partially solved using diagrammatic reasoning, under certain conditions. A related and equally important problem, called the Ramification Problem, is to be able to reason about the indirect effects of an action in the world. Our proposal provides a more efficient solution to the Ramification Problem when reasoning about spatial relations. To illustrate our solution, we introduce a problem solving architecture based on Soar that is augmented with a diagrammatic reasoning component. A problem state in this augmented Soar is bi-modal in nature, one part being symbolic and the other diagrammatic. We describe its use in certain problems and show how the use of diagrams can handle the frame and ramification problems with respect to spatial relations.

Kurup, U., & Chandrasekaran, B. (2007). Modeling Memories of Large-Scale Space Using a Bimodal Cognitive Architecture. In In Proceedings of 2007 Soar Workshop. Ann Arbor, MI. Also In Proceedings of Eighth International Conference on Cognitive Modeling (ICCM '07).

Key Words:

An Annotated Bibliography of Studies and Reports Produced by the Advanced Decision Architectures Consortium of the Collaborative Technology Alliance from 2001 to 2010

ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
We present an extension to biSoar, a bimodal version of the cognitive architecture Soar, by adding a bimodal version of chunking, Soar's basic learning mechanism. We show how this new biSoar is a useful tool in modeling cognitive phenomena involving spatial or diagrammatic elements by applying it to the modeling of problem solving involving large-scale space, such as way-finding. We suggest how such models can help in identifying variables to control for in human subject experiments.

Kurup, U., & Chandrasekaran, B. (2009). A Cognitive Map for an Artificial Agent. In In Proceedings of Artificial General Intelligence 2009 Conference in Arlington, VA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
We show how a general-purpose cognitive architecture augmented with a general diagrammatic component can represent and reason about Large-scale Space. The diagrammatic component allows an agent built in this architecture to represent information both symbolically and diagrammatically as appropriate. Using examples we show (a) how the agent's bimodal representation captures its knowledge about large-scale space as well as how it learns this information while problem solving and (b) the agent's flexibility when it comes to using learned information and incorporating new information in solving problems involving large-scale space.

Laplante, P., Hoffman, R. R., & Klein, G. (2007). Antipatterns in the Creation of Intelligent Systems. IEEE Intelligent Systems, JANUARY/FEBRUARY 2007, 91-95.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
A design pattern is a named problem-solution pair that enables large-scale reuse of software architectures or their components (that is, interface designs1). Ideally, patterns explicitly capture expert knowledge, design trade-offs, and design rationale and make these lessons learned widely available for off-the-shelf use. They can also enhance developers' vocabulary—for example, by easing the transition to object-oriented programming.2 Conventionally, patterns consist of four elements: a name, the problem to be solved, the solution to the problem (often termed the refactored solution), and the consequences of the solution. Numerous sets of patterns (collectively known as pattern languages) exist for software design, analysis, management, and so on; a Web search on "pattern language" yields many hits. Shortly after the notion of design patterns emerged, practitioners began discussing problem-solution pairs in which the solution did more harm than good.3,4 These have come to be known as antipatterns, and they are well known in the design and management communities.

Laughery, K. R., Jr., Archer, S., & Corker, K. (2001). Chapter 93. Modeling Human Performance in Complex Systems. In G. Salvendy (Ed.), Handbook of Industrial Engineering (3 ed., pp. 2409-2443). New York: John Wiley & Sons, Inc.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Over the past few decades, human factors and ergonomics practitioners have increasingly been called upon early in the system design and development process. Early input from all disciplines results in better and more integrated designs as well as lower costs than if one or more disciplines finds that changes are required later. Our goal as human factors and ergonomics practitioners should be to provide substantive and well-supported input regarding the human(s), his or her interaction(s) with the system, and the resulting total performance. Furthermore, we should be prepared to provide this input from the earliest stages of system concept development and then throughout the entire system or product life cycle.
To meet this challenge, many human factors and ergonomics tools and technologies have evolved over the years to support early analysis and design. Two specific types of technologies are design guidance (e.g., O'Hara et a1. 1995; Boff et al. 1986) and high-fidelity rapid prototyping of user interfaces (e.g., Dahl et al. 1995). Design guidance technologies, in the form of either handbooks or computerized decision support systems, put selected portions of the human factors and ergonomics knowledge base at the fingertips of the designer, often in a form tailored to a particular problem such as nuclear power plant design or UNIX computer interface design. However, design guides have the shortcoming that they do not often provide methods for making quantitative trade-offs in system performance as a function of design. For example, design guides may tell us that a high-resolution color display will be better than a black-and-white display, and they may even tell us the value in terms of increased response time and reduced error rates. However, this type of guidance will rarely provide good insight into the value of this improved element of the human's performance to the overall system's performance. As such, design guidance has limited value for providing concrete input to system-level performance prediction.
Rapid prototyping, on the other hand, supports analysis of how a specific design and task allocation will affect human and system-level performance. The disadvantage of prototyping, as with all human-subjects experimentation, is that it can be costly. In particular, prototypes of hardware-based systems, such as aircraft and machinery, are very expensive to develop, particularly at early design stages when there are many widely divergent design concepts. In spite of the expense, hardware and software prototyping are important tools for the human factors practitioner, and their use is growing in virtually every application area.
While these technologies are valuable to the human factors practitioner, what is often needed is an integrating methodology that can extrapolate from the base of human factors and ergonomics data, as reflected in design guides and the literature, in order to support system-level performance predictions as a function of design alternatives. This methodology should also bind with rapid prototyping and experimentation in a mutually supportive and iterative way. As has become the case in many engineering disciplines, a prime candidate for this integrating methodology is computer modeling and simulation.
Computer modeling of human behavior and performance is not a new endeavor. Computer models of complex cognitive behavior have been around for over 20 years (e.g., Newell and Simon 1972) and tools for computer modeling of task-level performance have been available since the 1970s (e.g., Wortman et al. 1978). However, two things have changed appreciably in the past decade that promote the use of computer modeling and simulation of human performance as a standard tool for the practitioner. First is the rapid increase in computer power and the associated development of easierto- use modeling tools. Individuals with an interest in predicting human performance through simulation can select from a variety of computer-based tools (for a comprehensive list of these tools, see McMillan et a1. 1989). Second is the increased focus by the research community on the development of predictive models of human performance rather than simply descriptive models. For example, the GOMS model (Gray et a1. 1993) represents the integration of research into a model for making predictions of how humans will perform in a realistic task environment. Another example is the research in cognitive workload that has been represented as computer algorithms (e.g., McCracken and Aldrich 1984; Farmer et al. 1995). Given a description of the tasks and equipment with which humans are engaged, these algorithms support assessment of when workload-related performance problems are likely to occur and often include identification of the quantitative impact of those problems on overall system performance (Hahler et al. 1991). These algorithms are particularly useful when embedded as key components in computer simulation models of the tasks. and the environment.
Perhaps the most powerful aspect of computer modeling and simulation is that it provides a method through which the human factors and ergonomics team can step up to the table with the other engineering disciplines that also rely increasingly on quantitative computer models. What we will discuss in this chapter are the methods through which the human factors and ergonomics community can contribute early to system design tradeoff decisions.

Laux, L., Laughery, R., Endsley, M., & Strub, M. (2003). Designing Systems around Soldier Decision Making and Situation Awareness: Improving C4isr Process. In In Proceedings of Army Science Conference. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In most military systems today enormous amounts of data are available to be presented to the soldier and the volume of available C4ISR data is continually increasing. Multiply this by the large numbers of formats (technologies) available for presenting these data and the decisions the interface and interaction designer must make become unmanageable without direction. This paper describes a methodology for managing this data overload problem through a structured process for maximizing solider situation awareness to improve decision making in C4ISR.

Laux, L., McDermott, P., Keller, J., & Laughery, R. (2006). Visualization, Cognitive Task Analysis, and Decision-Centered Design. In Presented at United States Strategic Command (USSTRATCOM) Command and Control (C2) Technology Summit: Data Visualization and Data Discovery/Access for Net-centric C2 Architectures, Bellevue, Nebraska.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Communication, Information, and Visualization
A user interface is a communication device. The Graphical User Interface (GUI) of a military application is a primarily visual (sometimes auditory) communication device intended to provide useful information and facilitate decision-making. In Information Theory terms, a GUI component such as a graphical display or text message only provides information when it communicates something the user doesn't already know and reduces uncertainty. The goal of creating/presenting visualizations is to increase the amount of information in a display or series of displays while concomitantly reducing the perceptual and cognitive load on the decision-maker.
Two trends suggest that we need to develop methods, such as visualizations, to reduce the perceptual and cognitive load on decision-makers who are receiving intelligence and other forms of information electronically:
1. Systems are becoming more automated and the role of decision-maker is shifting to that of system monitor (rather than "hands-on operator"). As systems become more automated, the types of decisions that must be made and the complexity of the data will make it more difficult for the decision-makers who monitor these systems to maintain situation awareness because they will not be engaged and in-the-loop. Visualizations, such as dynamic graphs, can be used to create pertinent status information and reduce the load associated with processing multiple sources of data.
2. Sensor and other technology advances provide us with more and more data/time period and these advances are expected to continue over the foreseeable future, meaning that the amount of data we have available to present to users is overwhelming – operators simply cannot efficiently process the amount of data we currently have to present them unless we can "condense" the data and turn it into meaningful information that can be quickly understood and assimilated. Visualizations can make multi-dimensional complex data readily understood.

Lebiere, C., Biefeld, E., Archer, R., Archer, S., Allender, L., & Kelley, T. D. (2002). IMPRINT/ACT-R: Integration of a Task Network Modeling Architecture with a Cognitive Architecture and Its Application to Human Error Modeling. In In Proceedings of Military, Government, and Aerospace Simulation (MGA 2002) Conference. Michael Chinni, (Ed.), pp. 13-18.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Task network model, cognitive architecture, IMPRINT, ACT-R, error modeling

Summary abstract:

This paper describes ongoing efforts to integrate IMPRINT (IMproved Performance Research INtegration Tool), a task network modeling architecture with ACT-R (Adaptive Character of Thought — Rational), a hybrid cognitive architecture. IMPRINT consists of a set of automated aids to conduct human performance analyses built on top of the Micro Saint task network modeling environment. ACT-R combines a goaldirected production system with a subsymbolic activation calculus that tunes itself to the structure of the environment using Bayesian learning mechanisms. Because ACT-R and IMPRINT were targeted at different behavioral levels, they perfectly complement each other. IMPRINT is focused on the task level, how high-level functions break down into smaller-scale tasks and the logic by which those tasks follow each other to accomplish those functions. ACT-R is targeted at the ÒatomicÓ level of thought, the individual cognitive, perceptual and motor acts that take place at the subsecond level. Goals in ACT-R correspond directly to tasks in IMPRINT, providing a natural integration level. Certain tasks in an IMPRINT task network can be implemented as ACT-R models, combining the cognitive accuracy of a cognitive architecture with the tractability and ease of design of task networks.
A hybrid IMPRINT/ACT-R model works as follows. The IMPRINT model specifies the network of tasks and includes the definition of how higher-order functions are decomposed into tasks and the logic by which these tasks are composed together. For certain tasks, IMPRINT sends to ACT-R over a Component Object Model (COM) link the state of variables providing a detailed description of that task. ACT-R then creates a goal corresponding to that task, with the components of the goal set to the description of the task. The ACTR model for that goal is then run, producing detailed cognitive predictions including latency of the run, whether an error occurred, etc. Those results are then passed back over the same COM link to IMPRINT, which uses them as parameters of the task to advance the task network model. We describe an application of this hybrid modeling to the prediction of human errors that lead to runway incursions. Finally, we discuss future extensions of our work, including the use of a standardized High Level Architecture (HLA) link to handle communications between IMPRINT and ACT-R and the extension of the task parameters exchanged to include workload predictions.

Lebiere, C., Gonzalez, C., & Martin, M. (2008). Instance-Based Decision Making Model of Repeated Binary Choice. In In Proceedings of Lewis, Polk, & Laird (Eds.), 8th International Conference on Cognitive Modeling (ICCM) (pp. 77-82). Ann Arbor, MI.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings Learning; dynamic decision making; RELACS; memory; cognitive architectures; ACT-R.

Summary abstract:
We describe an instance-based model of decision-making for repeated binary choice. The model provides an accurate account of existing data of aggregate choice probabilities and individual differences, as well as newly collected data on learning and choice interdependency. In particular, the model provides a general emergent account of the risk aversion effect that does not require any metacognitive assumptions. Advantages of the model include its simplicity, its compatibility with previous models of choice and dynamic control, and the strong constraints it inherits from the underlying cognitive architecture.

Lebiere, C., Gonzalez, C., & Warwick, W. (2009). A Comparative Approach to Understanding General Intelligence: Predicting Cognitive Performance in an Open-Ended Dynamic Task. In In Proceedings of Second Conference on Artificial General Intelligence. Atlantis Press, Amestrdam-Paris, pp.103-107.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The evaluation of an AGI system can take many forms. There is a long tradition in Artificial Intelligence (AI) of competitions focused on key challenges. A similar, but less celebrated trend has emerged in computational cognitive modeling, that of model comparison. As with AI competitions, model comparisons invite the development of different computational cognitive models on a well-defined task. However, unlike AI where the goal is to provide the maximum level of functionality up to and exceeding human capabilities, the goal of model comparisons is to simulate human performance. Usually, goodness-of-fit measures are calculated for the various models. Also unlike

AI competitions where the best performer is declared the winner, model comparisons center on understanding in some detail how the different modeling "architectures" have been applied to the common task. In this paper we announce a new model comparison effort that will illuminate the general features of cognitive architectures as they are applied to control problems in dynamic environments. We begin by briefly describing the task to be modeled, our motivation for selecting that task and what we expect the comparison to reveal. Next, we describe the programmatic details of the comparison, including a quick survey of the requirements for accessing, downloading and connecting different models to the simulated task environment. We conclude with remarks on the general value in this and other model comparisons for advancing the science of AGI development.

Lebiere, C., Gonzalez, C., & Warwick, W. (2009). Convergence and Constraints Revealed in a Qualitative Model Comparison. Journal of Cognitive Engineering and Decision Making, 3(2, Summer 2009), 131–155.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
We contrasted and compared independently developed computational models of human performance in a common dynamic decision-making task. The task, called dynamic stocks and flows, is simple and tractable enough for laboratory experiments yet exhibits many characteristics of macrocognition. A macrocognitive model was developed using a computational instantiation of recognition-primed decision making. A microcognitive model was developed using the Adaptive Control of Thought – Rational (ACT-R) cognitive architecture. Both models followed an instancebased learning paradigm and displayed striking similarities, including their constraints, limitations, and the key breakthrough that enabled satisfactory (though still short of human-like) performance, suggesting the emergence of a general design pattern. On the basis of this comparison we argue that although some substantive differences remain, microcognitive and macrocognitive approaches provide complementary rather than contradictory accounts of human behavior.

Lee, D.-S., Woods, D. D., & Kidwell, D. (2006). Escaping the Design Traps of Creeping Featurism: Introducing a Fitness Management Strategy. In In Proceedings of Usability Professionals' Association Annual Conference, Broomfield, CO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Creeping featurism is a process that produces complexity. This paper describes ways to prevent or escape from creeping featurism. We discuss limitations of current methods of user interface design and usability engineering, and propose a fitness management strategy to detect feature creep and to aid the search for innovations.

Lockett, J. F., III, & Archer, S. (2009). Chapter 51. Impact of Digital Human Modeling on Military Human-Systems Integration and Impact of the Military on Digital Human Modeling. In V.G. Duffy (Ed.), Handbook of Digital Human Modeling. 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487-2742: CRC Press. Taylor & Francis Group.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section
Human Figure Models

Task Models
Cognitive Models
Information Flow Models
Integrated and Hybrid Models and Tools
Analysis Approach
Application Issues
Case Studies
Number of Operators and Workload
Light Helicopter Experimental (LHX) and NBC
Fox Operator Workload Analyses
The Future Combat System (FCS)
Brigade Staffing
Information Flow
Command and Control Case Study
CART Case Study
Maintenance Manpower
JBPDS Case Study
Decision Making
GRBIL Case Study
Workspace Analysis Using Human
Figure Models
Future Combat System (FCS)
A Common Approach
Advanced Amphibious Assault Vehicle
Comanche Helicopter
Stryker
Army Airborne Command and Control System (A2C2S)
Future Challenges and Development

Summary abstract:
Military organizations have driven much of the research and development in ergonomics and huma 1\ factors engineering and as a result have realized significant benefits. During the past three decades. these organizations made significant investments in development of digital human models as tools 10 enable human systems integration. Use of these models has resulted in earlier identification of usabil ity issues, increased opportunity to resolve those issues less expensively, and more effective and sati.,r systems. In this chapter, we review these developments and discuss their application via case studies Although military investment is certainly not limited to the United States Department of Defense (DoD), given the basis of our experience, this is our focus. Additional discussion of these develop • ments and human systems integration can be found in, for example, Booher (1990, 2003) and Salvendy (2006).
Digital human models represent a wide range of human physical, mental, and social attributes and behaviors. Many of the models and the analysis tools in which they have been embedded characterize multiple attributes and so are not easily categorized. However, the following categories are useful in describing the predominant attributes represented by the models most commonly used for human sys terns integration (HSI). They are human figure models, task models, cognitive models, information flow models, and integrated or hybrid models.

Lott, J., Bradshaw, J. M., Uszok, A., & Jeffers, R. (2004). Using KAoS Policy and Domain Services within Cougaar. In In Proceedings of Open Cougaar Conference 2004. New York City, NY.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
KAoS policy and domain management services allow for the specification, management, conflict resolution, and enforcement of policies represented in OWL within contexts established by domains. We discuss the application of KAoS services in providing policy management for robustness and survivability in the context of the DARPA

UltraLog program, a large-scale distributed agent-based system running on the Cougaar agent infrastructure. Over the course of the program we were able to demonstrate that a semantically-rich policy system could provide exceptional performance and responsiveness even under very demanding conditions

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Luck, J., McDermott, P. L., Allender, L., & Fisher, A. (2006). Advantages of Co-Location for Effective Human to Human Communication of Information Provided by an Unmanned Vehicle. In In Proceedings of 50th Annual Meeting of the Human Factors and Ergonomics Society, San Francisco, CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Much of the research on unmanned-vehicles (UVs) focuses on technology or interface design. This study investigated how to best support effective communication between the UV operator and the Soldier in the field using UV-provided information to complete a mission. In a previous study investigating the impact of different team configurations and the utility of supporting communication technologies, our team found co-location of team members to be beneficial (McDermott et al., 2005). In this experiment we investigate what aspects of colocation are key to successful team performance: Is face-to-face communication vital compared to voice-only when team members are distributed? Is the ability of the UV operator to see what the Soldier performing the mission can see critical? We also seek additional insight to inconclusive results from the first study regarding the utility of image transmission and access to an electronic map displaying both the UV and Soldier locations.

Luck, J. P., McDermott, P. L., & Allender, L. (2005). The Communication of UAV-Provided Information. In In Proceedings of Annual Human Factors of UAVs workshop. Mesa, AZ.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Unmanned Aerial Vehicles (UAV) have enormous potential to help infantry soldiers navigate safely by providing information about enemy locations and other obstacles. Our research focuses on real-time communication between a person monitoring UAV-provided information and a soldier in the field using the information to execute a mission. One practical consideration is the location of the operator monitoring the UAV. Can this “Information Manager” (IM) be positioned rearward at a command center or should the IM be co-located with the soldiers in the field? There are potential advantages and disadvantages to either location. A co-located IM has excellent and immediate awareness of the situation in the field – what the soldiers are looking at, where they are located, and subtle cues such as the attitude of civilians on the street. Likewise, it should be easier for a co-located IM to discern when his unit leader is confused or misunderstood UAV-provided information. The disadvantage of being co-located is the high workload demands of monitoring the information provided by the UAV, reconciling that information to the unit’s current location, and performing necessary infantry tasks (i.e., move, use cover and concealment, defend the unit if necessary, etc). A rearward located IM does not have these workload and safety issues but is less aware of the situation in the field. Can technological advances such as GPS tracking be used to increase the IM’s “immersion” in the infantry unit’s situation? This study investigated the implications of three team configurations on performance: a co-located IM, are rearward IM, and a rearward IM with access to a digital map updated in real-time with the soldier’s and UAV’s location.
An experiment was performed using the video game Raven Shield as a battlefield simulator. U.S. Marine Corps participants operated in two-person teams to conduct move-to-objective scenarios similar to “Black-Hawk Down.” A friendly helicopter has crashed in enemy territory and a Rescue Mission (RM) player is tasked to navigate to the downed pilot as quickly as possible without being detected by enemy forces. The IM uses a UAV to scout a route and guide the RM to the crash site along a route that avoids the enemy. Quantitative performance measures included the time to complete the mission and the number of detections by the enemy. This poster will concentrate on analysis of the post-mission questionnaires and verbal protocols between the IM and RM. The questionnaire asked participants to rate the difficulty of communicating locations, usefulness of UAV-provided information, and overall situation awareness. The verbal protocols were analyzed to understand the types of mistakes made with the UAV,

the mistakes averted because of the UAV, how the asset was used (i.e., to provide a high-level overhead view or a street level view), the push and pull of information between the team members, and the types of commands given to the RM. The implications for UAV team configurations will be discussed.

Luck, J. P., McDermott, P. L., & Allender, L. (2006). An Investigation of Situational Awareness in Real World Control of Robotic Assets with Communication Latency. In In Proceedings of the 3rd Annual Human Factors of Unmanned Aerial Vehicles Workshop. Mesa, AZ.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Unmanned vehicles (UVs) are already being used in a variety of applications, including the military battlefield. The applications will only increase as robotic technology, such as autonomy, continues to advance. As the technology advances, the number of applications will increase, as will the demands on the associated network. Limited bandwidth, extended transmission ranges, and high network traffic can all result in communication latency. A previous publication summarized the effects on operator performance from two experiments investigating the effects of communication latency when controlling a robot (Luck, 2006). This paper will detail the effects on operator Situational Awareness (SA) from the same two experiments.
The experimental task was a simulated MOUT reconnaissance in which participants drove an UV through four courses. Participants were given a map depicting the route and the location of reconnaissance “spins”. At three pre-determined points the participants were instructed to stop, the map was hidden, and participants attempted to mark the UV’s location and to retrace the route of the UV as accurately as possible, including deviations from the intended route. Participants also provided subjective ratings of SA after each mission and filled out a subjective questionnaire at the conclusion of the experiment.
One current thrust in robotics aims to increase the Level Of Automation (LOA) of robots. The rationale is that, reducing the amount of control required of the operator will extend the utility of the robot and simultaneously reduce operator workload. The results from this study indicate that increasing the LOA will also decrease the impact of latency duration on operator SA. The number of stoppages to gain SA and the number of SA marking errors (i.e., incorrectly marking the UV location, rooms entered, and location of driving errors) were all significantly lower under the higher compared to the lower LOAs tested.
The duration of latency also impacted operator SA. No significant effects on the ability to guide the robot along the proper route were found. However, significantly more marking errors were made with short delays than long delays. This counter-intuitive result most likely indicates that the higher level of concentration required with longer delays aids operators in maintaining SA.
Communication latency can also arise in different forms. Latency duration may be constant, as with hardware or path induced delays (ex: satellite-based communication), or may fluctuate due to varying traffic or routing conditions (ex: typical internet based communication). Significant effects on control performance were found for varying latency (Luck, 2006), however very few effects are seen for SA. While subjective ratings indicate more time was spent on maintaining SA under variable latency, there was only one measured effect on SA: Participants made more incorrect markings of drive error locations in variable latency. Accordingly varying latency has little effect on overall operator SA, but may require more effort and have a negative effect on an operators ability to remember small events while en route to a known goal.
Latency conditions may also differ between commands sent from the user to the robot (U2R) and feedback sent from the robot to the user (R2U). Perceived difficulty in maintaining SA was much larger when feedback was delayed then when control signals were delayed. Participants also made more navigation mistakes in the R2U condition, however no differences in marking mistakes were found.
Before making decisions about both the use and design of UV interfaces and systems, it is important to understand the impact of all of these factors on an operator’s ability to maintain awareness of the situation.

Luck, J. P., McDermott, P. L., Allender, L., & Russell, D. C. (2006). An Investigation of Real World Control of Robotic Assets under Communication Latency. In In Proceedings of ACM Human Robot Interaction Conference, Salt Lake City, UT.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Categories and Subject Descriptors
J.4 [Social and Behavioral Science]; J.7 [Computers in Other Systems], Military; Human Factors.
General Terms
Performance, Experimentation, and Human Factors.
Keywords
Latency, Delay, Communication, Teleoperation, Robotics, Control, and Level of Automation

Summary abstract:
Robots are already being used in a variety of applications, including the military battlefield. As robotic technology continues to advance, those applications will increase, as will the demands on the associated network communication links. Two experiments investigated the effects of communication latency on the control of a robot across four Levels Of Automation (LOAs), (1) full teleoperation, (2) guarded teleoperation, (3) autonomous obstacle avoidance, and (4) full autonomy. Latency parameters studied included latency duration, latency variability, and the “direction” in which the latency occurs, that is from user-to-robot or from robot-to-user. The results indicate that the higher the LOA, the better the performance in terms of both time and number of errors made, and also the more resistant to the degrading effects of latency. Subjective reports confirmed these findings. Implications of constant vs. variable-latency, user-to-robot vs. robot-to-user latency, and latency duration are also discussed.

Malkin, R. G., & Waibel, A. (2005). Classifying User Environment for Mobile Applications Using Linear Autoencoding of Ambient Audio. In In Proceedings of ICASSP-05. Philadelphia, PA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Many mobile devices and applications can act in contextsensitive ways, but rely on explicit human action for context awareness. It would be preferable if our devices were able to attain context awareness without human intervention. One important aspect of user context is environment. We present a novel method for classifying environment types based on acoustic signals. This method makes use of linear autoencoding neural networks, and is motivated by the observation that biological coding systems seem to be heavily influenced by the statistics of their environments. We show that the autoencoder method achieved a lower error rate than a standard gaussian mixture model on a representative sample task, and that a linear combination of autoencoders and GMMs yielded better performance than either alone.

Martin, M. J., & Foltz, P. W. (2004). Automated Team Discourse Annotation and Performance Prediction Using Lsa. In In Proceedings of Human Language Technology conference / North American chapter of the Association for Computational Linguistics Annual Meeting HLT/NAACL 2004.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
We describe two approaches to analyzing and tagging team discourse using Latent Semantic Analysis (LSA) to predict team performance. The first approach automatically categorizes the contents of each statement made by each of the three team members using an established set of tags. Performance predicting the tags automatically was 15% below human agreement. These tagged statements are then used to predict team performance. The second approach measures the semantic content of the dialogue of the team as a whole and accurately predicts the team.s performance on a simulated military mission.

Martin, M. K., Gonzalez, C., & Lebiere, C. (2004). Learning to Make Decisions in Dynamic Environments: ACT-R Plays the Beer Game. In In Proceedings of 6th International Conference on Cognitive Modeling. Pittsburgh, PA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Sterman (1989) proposed that decision makers misperceive the feedback provided by dynamically complex environments, and questioned whether people can learn to make effective decisions in such environments. We provide empirical evidence of learning in a well-known dynamic environment called the beer game. We then describe a preliminary version of an instance-based, dynamic decision making model built using the ACT-R cognitive architecture. The model mimics the general patterns of human behavior observed for aggregate performance across trials and local performance within trials. Implications for research on dynamic decision making are summarized.

Martinez, S. G., Talcott, C., Bennett, K. B., Stansifer, C., & Shattuck, L. (2001). Cognitive Systems Engineering Analyses for Army Tactical Operations. In In Proceedings of 45th Annual Meeting of the Human Factors and Ergonomics Society. Minneapolis, MN.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The Cognitive Systems Engineering (CSE) approach has been applied successfully for domains in which the interaction is primarily driven by either the laws of nature or by user intentions. We have initiated a research program to apply the CSE approach to a domain that is driven by both. We describe the preliminary results of our initial efforts, primarily a work domain analysis using the abstraction hierarchy analytical tool. Overall, the CSE approach has proven to be very useful for analysis and design. The adversarial nature of the domain poses certain challenges. For example, information regarding both friendly and enemy forces is critical to decision making. However, the representations that have been developed for friendly forces cannot be used to represent enemy forces, due to a lack of critical information. We view these as inherent challenges associated with this type of domain, rather than as a shortcoming of the CSE approach.

Matessa, M., Archer, R., & Mui, R. (2007). Dynamic Spatial Reasoning Capability in a Graphical Interface Evaluation Tool. In In Proceedings of Eighth International Conference on Cognitive Modeling (ICCM '07).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This paper describes dynamic and spatial reasoning enhancements to the Graph-Based Interface Language tool (GRBIL), which creates ACT-R models by demonstration. A new ability for users to create monitors enables procedures to be dynamically triggered. A new integration of ACT-R with a diagrammatic reasoning theory allows ACT-R to perform spatial reasoning. Capabilities of the tool are demonstrated in a robotic control task.

Matessa, M., & Brockett, A. (2007). Using a Diagram Representation System with ACT-R. In In Proceedings of Sixteenth Conference on Behavior Representation in Modeling and Simulation (BRIMS '07).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:

The ACT-R cognitive architecture has shown an increasing ability to account for human visual information processing. However, limitations currently exist that can be remedied by the integration of theories of diagrammatic representation. A demonstration of integration of ACT-R with a diagram representation system (DRS) is presented that addresses some current limitations.

Matessa, M., & Mui, R. (2009). Chapter 13. GRBIL: A Tool for Dynamic Operator and Environment Modeling. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section II. Presenting Battlefield Information to Warfighters: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
Human performance models can be very useful in predicting behavior. However, for dynamic situations it may be difficult to model both a changing environment and the processes needed to react to that environment. This chapter describes the Graph-Based Interface Language (GRBIL) tool which allows the modeling of an environment with a task network model, the creation of an interface for observing that environment using drag-and-drop functionality, and the modeling of a human operator of that interface with a cognitive architecture. Using both modeling approaches capitalizes on the advantages of each (the intuitive graphical representation of task network modeling and the detail of the cognitive architecture). To enable our goal of making the system usable to non-modeling experts, operator models are created by demonstrating procedures on the interface.

Matthews, M. D., Strater, L. D., & Endsley, M. R. (2004). Situation Awareness Requirements for Infantry Platoon Leaders. Military Psychology, 16(3), 149-161.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Situation awareness (SA) is a construct closely linked to decision making and performance. Identifying SA requirements for specific jobs is a necessary first step in accurately assessingSA,developing trainingprogramstoenhanceSAskills,andevaluating the impact of newtechnology on SA. This research identified the SA requirements for infantry small unit leaders. Six highly experienced infantry subject matter expertswere given semi-structured, in-depth interviews. The resulting SA requirements hierarchy contained 7 primary goals and multiple subgoals. Situation awareness requirements are job and mission specific. The methods used here may be adapted to identifySArequirements in other domains characterized by small, cohesive teams operating in dynamic environments and as the basis for developing SA metrics in these domains.

Mattingly, J., & Warwick, W. (2008). Projectible Predicates in Analogue and Simulated Systems. Synthese, 169, 465-482.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance

Book Chapter/Section
Computational modeling · Analogue modeling · Human performance · Theory structure

Summary abstract:
We investigate the relationship between two approaches to modeling physical systems. On the first approach, simplifying assumptions are made about the level of detail we choose to represent in a computational simulation with an eye toward tractability. On the second approach simpler, analogue physical systems are considered that have more or less well-defined connections to systems of interest that are themselves too difficult to probe experimentally. Our interest here is in the connections between the artifacts of modeling that appear in these two approaches. We begin by outlining an important respect in which the two are essentially dissimilar and then propose a method whereby overcoming that dissimilarity by hand results in usefully analogous behavior. We claim that progress can be made if we think of artifacts as clues to the projectible predicates proper to the models themselves. Our degree of control over the connection between interesting analogue physical systems and their targets arises from determining the projectible predicates in the analogue system through a combination of theory and experiment. To obtain a similar degree of control over the connection between large-scale, distributed simulations of complex systems and their targets we must similarly determine the projectible predicates of the simulations themselves. In general theory will be too intractable to be of use, and so we advocate an experimental program for determining these predicates.

McCulloh, I., & Carley, K. M. (2009). Detecting Change in Human Social Behavior Simulation. In In Proceedings of Conference at Carnegie Mellon University, School of Computer Science, Institute for Software Research, Technical Report CMU-ISR-08-135.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Social network change detection, statistical process control, multi-agent simulation, military, organizational behavior, networks, network statistics

Summary abstract:
The performance of social network change detection (SNCD) is evaluated using a multi-agent simulation of company level U.S Army Infantry organizations. Agent interaction is probabilistic, with increased likelihood of communication based on similarity in skills, role, sub-unit of assignment, military rank, and general personality homophily. Various social network measures are monitored for change over time with a Cumulative Sum (CUSUM) control chart, an Exponentially Weighted Moving Average (EWMA), a scan statistic, and a Hamming Distance. Findings show that the average betweenness, the average closeness, and the standard deviation of eigenvector centrality are social network measures that are well-suited for SNCD. This research further supports the efficacy of SNCD using statistical process control charts.

McCulloh, l., Webb, M., Graham, J., Carley, K., & Horn, D. B. (2008). Change Detection in Social Networks. In In Proceedings of U.S. Army Research Institute for the Behavioral and Social Sciences, Technical Report No. ARI-TR-1235. Arlington, VA. DTIC ADA484611.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Fields and Groups:
250200 - Radio Communications
Descriptors:
(U) *CHANGE DETECTION, *COMMUNICATIONS NETWORKS, TERRORISM, ELECTRONIC MAIL, COMMAND AND CONTROL SYSTEMS, ALGORITHMS, STATISTICAL PROCESSES
Identifiers:
(U) *SOCIAL NETWORKS

Summary abstract:

Social network analysis (SNA) has become an important analytic tool for analyzing terrorist networks, friendly command and control structures, and a wide variety of other applications. This project proposes a new method for detecting change in social networks over time, by applying a cumulative sum statistical process control statistic to normally distributed network measures. The proposed method is able to detect organizational change in the same manner as a quality engineer can detect a change in a manufacturing process. The new algorithm is demonstrated on social network data collected on a group of 24 Army officers going through a 1-year graduate program at Columbia University and on al-Qaeda leading up to and immediately following the terrorist attacks of September 11, 2001.

McDermott, P., & Allender, L. (Eds.). (2009). Advanced Decision Architectures for the Warfighter: Foundations and Technology: 48hrBooks by the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. http://www.arladacta.info.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book

Summary abstract:
x

McDermott, P., Hutchins, S., Barnes, M., Koenecke, C., Gillan, D., & Rothrock, L. (2003). The Presentation of Risk and Uncertainty in the Context of National Missile Defense Simulations. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society Confernece. Denver, CO. (pp. 562-566).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Risk perception and uncertainty management are important components of military decision making, especially in time-stressed and resource-limited environments. The purpose of this experiment was to understand the interaction of integrality of information, presentation mode, and information frame on situation awareness (SA) and decision-making (missile allocation) in a National Missile Defense (NMD) paradigm. Results of the information frame manipulation (expected gain v. expected loss) support earlier findings that subjects are loss averse. SA Accuracy was higher with graphical displays than alphanumeric displays. The implications for NMD are discussed.

McDermott, P. L., Fisher, A., Allender, L., & Luck, J. (2008). To Send or Not to Send: Does the Transmission of Unmanned Vehicle Imagery Help or Hinder Soldier Performance? In In Proceedings of 5th Annual Workshop of Human Factors in UAVs: Human Factors Issues in Imagery Analysis using Unmanned Aerial Vehicles, Apache Junction, AZ.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Summary
• Image transmission is useful to direct teammate if done correctly
• Especially useful when teammates were distributed
• Biggest factor – does the recipient know where he or she is in relation to the image
• Show recipient in the image
• Give the recipient landmarks so they can orient themselves
• UAV imagery provided an overview; UGVs were better at detecting enemy

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McDermott, P. L., Barnes, M., & Hutchins, S. (2005). Too Little or Too Much: The Effect of Feedback on Risk Assessment in a Missile Defense Task. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Operators must often assess risk and take actions in proportion to that risk. This is not an inherently easy task and based on previous experiments, visualization aids may not be the entire solution to aiding operators. This experiment explored the impact of feedback paradigms on performance in a national missile defense (NMD) task. Participants had extensive practice with one of three types of feedback styles: averaged results after a set of scenarios, constant feedback after every scenario, or constant feedback with forced reflection. This study has three main contributions to decision-making research.
1) Although the trust in automation literature shows that averaged feedback increases understanding of the relative frequency of errors, this NMD task showed that constant feedback is more effective than averaged feedback.
2) Participant performance was still improving after three sessions, suggesting the need for more intense training.
3) NMD provides a concrete domain with viable metrics for investigating the perception of risk and uncertainty.

McDermott, P. L., Barnes, M., & Hutchins, S. (2009). *Displays and Decisions - the Chicken or the Egg? The Influence of Displays on the Decision Making Process. In In Proceedings of 9th Naturalistic Decision Making Conference, London, England.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Decision making process, design cycle, visualizations, courses of action.

Summary abstract:
Motivation – The goal is to encourage discussion on the philosophical approach to studying decision making. Research approach – A full design cycle included cognitive task analysis (CTA), display design, analysis of alternatives, and redesign. Findings – The visualizations influenced the decision process and the courses of action. Research Implications – This example illustrates an interesting question regarding decision making for envisioned problems and whether the designers should start by understanding how future operators are likely to think about the problem or by designing alternatives and studying their impact on decision making and course of action selection. Originality/Value – Multiple phases of a naturalistic design process are discussed as well as the impact of those displays on decision strategies. Take away message – Even when the design process starts with a CTA, it is important to examine how different ways of presenting or interacting with data effect how operators think about the task and take action.

McDermott, P. L., Bolstad, C., Jamieson, G., Laux, L., Shattuck, L., & Wickens, C. (2005). Good Design Ideas Gone Bad: Lessons Learned When System Designs Do Not Work as Planned. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
If at first you don’t succeed, try again. Often the first or second design alternatives are modified or discarded based on preliminary evaluation. However, there is much to be learned from design ideas that did not work as planned. Unfortunately, the lessons learned from these inadequate designs are not always shared within the human factors community. This panel provides a forum to share the lessons learned by panelists who are actually creating and evaluating designs in the field. The panelists represent a balance of perspectives from academia, industry, and government. Attendees should come away from the session with concrete examples of inadequate interface designs,

how they were improved, and an understanding of why the design did not work for a particular application. A successful panel will create a forum to share lessons learned and perhaps prevent practitioners from repeating work that has already been done.

McDermott, P. L., & Fisher, A. (2009). The Tradeoff of Frame Rate and Resolution in a Route Clearing Task: Implications for Human-Robot Interaction. In In Proceedings of 53rd Annual Meeting of the Human Factors and Ergonomics Society, San Antonio, TX.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The implications of bandwidth allocation are described for teleoperation in a military task that involved navigation, target detection, and target identification. Color versus grayscale imagery was manipulated. Participants themselves traded off resolution and frame rate settings. Participants minimized switching between resolution/frame rate settings and tended to use settings with high resolution/low frame rate. Courses completed with the highest resolution (and lowest frame rate) had the fastest target identification times, but no other differences were observed between settings. Color imagery offered advantages for overall course time and the time to identify a tank as friendly or enemy.

McDermott, P. L., Fisher, A., & Allender, L. (2008). The Transmission of Spatial Route Information in Distributed Unmanned Vehicle Teams. In In Proceedings of 52nd Annual Meeting of the Human Factors and Ergonomics Society. 22-26 September 2008. New York City, NY USA. New York City, NY USA: HFES.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The purpose was to understand the utility of different methods of communicating spatial information between distributed team members. An unmanned vehicle (UV) operator used a UV to scope out safe routes and enemy locations and used that information to help a Soldier conduct a rescue mission. There were four communication methods: visual, verbal, real-time verbal plus visual (VPV), and delayed VPV. We manipulated who was in command to see the impact on both pushed and pulled information. Results showed advantages of both visual and real-time VPV. We also found that with delayed VPV, the Soldier communicated infrequently which resulted in poorer performance, especially when the Soldier was in command. Results inform how beneficial UV information should be transmitted to Soldiers who need it in the field.

McDermott, P. L., Gillan, D., Riley, J., & Allender, L. (2009). Chapter 16. Five Lessons Learned in Human-Robot Interaction. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section III. Acting on Battlefield Information: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
The growing sophistication of robotics systems has enhanced the utility of unmanned systems for complex military operations (e.g., ordnance disposal or minefield remediation, Lemhofer, 1999; aerial reconnaissance and patrol, Chappell, 2007). The increasing capability and functionality of current and future robotics systems design requires

comparable enhancements to robotics interfaces and displays developed for controlling unmanned systems. Many military operations involving robotic assets still require some level of teamwork, so the interfaces must not only support single user control, but also promote team processes. Furthermore, displays and interactions mechanisms must be designed to facilitate quick and smooth transitions between multiple users collaborating to control multiple robots. This may occur under varying levels of autonomy and in a variety of tasks.
Our goal for this research was to improve the human-robot interaction (HRI) through study of factors that impact aspects of Soldier performance in robotics operations. The research team identified key issues and challenges in monitoring and controlling robots with respect to situation awareness (SA), perception and performance, and workload. SA Technologies, Alion, New Mexico State University, and North Carolina State University have conducted numerous studies to understand a wide variety of factors that will affect Soldiers' interactions with robots. These include the impact of bandwidth reduction, span of control, unmanned vehicle characteristics, level of automation, and interface designs (including control and feedback from the robot) as well as collaborative technologies and teamwork configurations. The research has included both theoretical and empirical investigations in a variety of contexts (e.g., search and rescue, homeland security operations, and military reconnaissance) and experimental mediums (e.g., real-world miniature environments, virtual environments, computer games, and field studies). Our HRI research has investigated mUltiple factors. that can impact SA (and performance) including: mission or task factors, environmental factors, human and social factors, system design factors, and aspects of interface design. This paper summarizes five key lessons learned from this multiple- year research program within the Advanced Decision Architectures Collaborative Technology Alliance:
1. System and interface design must support the multiple facets of SA.
2. Operating a robot inherently requires mUltitasking. One solution to the human performance costs of multitasking is to automate certain tasks, but the effects of automation on performance may be limited by human and social factors.
3. Soldier-robot interfaces need to support effective teamwork and the communication of spatial information.
4. Soldiers need interface interventions and compensatory methods to ameliorate the effects of remote presence (e.g., reduction on natural ability to perceive, move, and manipulate objects in an environment) that can hinder navigation and limit Soldier ability to project his intent upon the environment.
5. Performance measures must be examined in tandem with SA measures to get better assess the effects of HRI factors on overall system performance.

McDermott, P. L., & Hautamaki, B. (2007). Resource Allocation Decisions: The Impact of Individual Differences on Preferences and Performance. In In Proceedings of K.Mosier & U. Fischer (eds.), Proceedings of the Eighth International Conference on Naturalistic Decision Making.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Key findings:
A “golden” criteria can be more important than others, but the specific criteria changes depending on the situation demands.
The info on the decision aid is just part of what makes up the decision; decisions are made in the context of METT-TC.
An understanding of the specific info considered.
Current systems solve for the optimal location of one sensor; they do not address the configuration of a suite of sensors.

McDermott, P. L., Luck, J., Allender, L., & Fisher, A. (2005). Effective Human to Human Communication of Information Provided by an Unmanned Vehicle In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Much of the research on unmanned-vehicles (UVs) focuses on technology or interface design. This study however, investigated how to best support effective communication between the operator monitoring a UV and the Soldier in the field using that information to complete a mission. Several questions arise: Does the operator need to be co-located with Soldiers in the field or can he or she be in a more secure rearward location? Does the team need the capability to transmit visual images or is radio communication adequate? Is information from one type of UV better than others? Do real time mapping and tracking technologies increase situation awareness (SA)? To begin to answer these questions, military teams conducted rescue missions using the video game Raven Shield as a simulated battlefield. The analysis of performance data, self reports, and observations provide some valuable insight to these questions.

McNeese, M. D., Bains, P., Brewer, I., Brown, C., Connors, E. S., Tyrone Jefferson, J., Jones, R. E. T., & Terrell, I. (2005). The Neocities Simulation: Understanding the Design and Experimental Methodology Used to Develop a Team Emergency Management Simulation In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This paper describes the continued development of a scaled-world simulation designed to conduct empirical research on team cognition and decision-making within a distributed environment. The NeoCITIES simulation was created to study decision-making and the impact of hidden knowledge profiles on team performance within a distributed command, control, and communications (C3) setting. NeoCITIES has been designed for the purpose of representing both new and operationally relevant scaled worlds, while emulating the complexities and attributes of emergent decision-making scenarios involving emergent counterterrorism events. Because patterns of activity emerge across time, knowledge is often hidden and disconnected within and across teams. NeoCIITES has been orchestrated to assess and evaluate the extent to which teams can socially construct knowledge while ineteracting through various means of technological support. Specifically, NeoCITIES is an interactive computer program designed to display information pertaining to events and occurrences in a virtual city space. The teams in the simulation represent three separate services (e.g., Police, Fire/EMS, and Hazmat) in which they must assess situations, interact and communicate according to their inter-team and intra-team roles, allocate resources in a timely manner, and make decisions within the context of emergency crisis management. Once NeoCITIES development has been completed, the simulation will be used as an experimental task to measure the impact of hidden knowledge profiles on teamwork and decision-making in the distributed team context.

Militello, L. G., & Hoffman, R. R. (2008). The Forgotten History of Cognitive Task Analysis. In In Proceedings of 52nd Annual Meeting of the Human Factors and Ergonomics Society. 22-26 September 2008. New York City, NY USA. New York City, NY USA: HFES.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Many reports of recent research on topics in cognitive systems engineering describe their methods by distinguishing cognitive task analysis from ―traditional or ―behavioral task analysis. A hallmark of modern cognitive task analysis (CTA) methods is that they place primary focus on understanding the cognitive demands of a task and the knowledge and strategies that underlie performance. While cognitive task analysis may have seemed to be a revolutionary approach introduced in recent years, a review of the history of task analysis reveals many things that have been lost in modern treatments of the history of human factors. This presentation will review some highlights of this forgotten history, including the ideas and methods of the Psychotechnicians, the earliest industrial psychologists, the Taylorists, and others who contributed to modern CTA. Task analysis never lacked cognitive categories. Even microscale time and motion studies involved the analysis of the work of domain experts. Basic

ideas of human-machine systems and of complexity also appear in some of the earliest literatures industrial psychology of the first decades of the 20th century.

Militello, L. G., Patterson, E. S., Bowman, L., & Wears, R. (2007). Information Flow During Crisis Management: Challenges to Coordination in the Emergency Operations Center. Cognition, Technology and Work, 9(1), 25-31.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Emergency operations center Crisis
management Team decision making Team
coordination Cross agency collaboration

Summary abstract:
This paper discusses challenges to coordination in the emergency operations center (EOC). A county-level EOC is made up of representatives from a range of organizations including local government, fire, police, hospital, utility, and Red Cross representatives. These ad hoc teams are tasked with coming together during an emergency to obtain and deliver resources to first responders on the scene of the disaster, as well coordinating transportation of casualties, tracking of fatalities, and establishment of shelters. Two county-level exercises were observed. Themes were identified across the two exercises. Recommendations for better supporting coordination in crisis management are offered.

Miller, J. E., Patterson, E. S., & Woods, D. D. (2003). Elicitation by Critiquing: An Exploratory Study. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society Conference. Denver, CO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Knowledge elicitation methods uncover information about how a practitioner works in a field. However, these methods have the challenges of grounding in context, accessibility to experts and tasks, being laborious and lime consuming, and repeatability. This study investigated a critiquing methodology's ability to address these challenges while still being authentic and generative. The domain investigated was military intelligence analysis, a field that experiences a constant turnover of workers. To maintain the highest level of productivity, the expertise of their military intelligence analysis practitioners must be understood. A study was done involving a novice performing a basic analysis task. Then, six experts with various backgrounds critiqued the novice's process. The results suggest that the critiquing method addresses the challenges of knowledge elicitation methods while being authentic and generative. The specific guiding question for addressing both issues was 'Can the critiquing method be used to help unveil expertise in intelligence analysis?'

Miller, N. L., & Shattuck, L. G. (2004). A Process Model of Situated Cognition in Military Command and Control. In In Proceedings of Command and Control Research and Technology Symposium (9th), held in San Diego, CA, Jun 2004. Published in the Proceedings of the Command and Control Research and Technology Symposium (9th), 2004: The Power of Information Age Concepts and Technologies. San Diego, CA. DTIC ADA466093.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Fields and Groups:
230200 - Human Factors Engineering & Man Machine System
250500 - Command, Control and Communications Systems
Descriptors:

(U) *COGNITION, *COMMAND AND CONTROL SYSTEMS, METHODOLOGY, HUMAN FACTORS ENGINEERING, MAN MACHINE SYSTEMS, CASE STUDIES, SYMPOSIA

Summary abstract:
Complex cognitive systems couple humans with machines for the purpose of accomplishing a specific goal. It is often the case that human factors practitioners focus their attention on the humans while designers tend to focus on the technological aspects of the system. The point of intersection between humans and technology has become a boundary with respect to evaluation. In addition, human factors practitioners have often studied the result of cognitive activity (e.g., a decision) rather than the processes that lead to the outcome. In this paper, the authors present a general model that combines the technological aspects of a system with the perceptual and cognitive processes of the humans embedded in the system. The model emphasizes that such systems are both process oriented and dynamic. The authors describe a process tracing methodology that can be used to investigate the flow of data and information through both the technological and human components of the system. The attack on the USS Stark is used as a case study to illustrate the model and the process tracing methodology. The results of the process tracing analysis have implications for the design of complex systems and the training received by those who operate such systems.

Miller, T. E., Stanard, T. W., & Wiggins, S. L. (2003). Applying Decision Centered Design to Damage Control for the Navy. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society Conference. Denver, CO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Decision-Centered Design (DCD) was created so that the users of information technology (IT) have an advocate in the design cycle. DCD was created to increase the value of IT for the decision maker. It is a cognitive engineering approach to design that uncovers and models the cognitive expertise of users and conveys these insights to IT developers. DCD ensures that cognitive challenges are addressed in IT designs so that cognitive performance is improved. Other cognitive engineering approaches share these same goals, but DCD also has principles and processes that other cognitive engineering approaches may not share. This paper will use a Damage Control decision support system to illustrate the application of DCD.

Montanari, R., Toninelli, A. and Bradshaw, J. M. (2005). Context-Based Security Management for Multi-Agent Systems. In In Proceedings of Second IEEE Symposium on Multi-Agent Security and Survivability (MASS 2005), Philadelphia, PA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Policies are being increasingly used for controlling the behavior of complex multi-agent systems. The use of policies allows administrators to specify both agent permissions and duties without changing source code or requiring the consent or cooperation of the agents being governed. However, policy-based control can encounter difficulties when applied to agents that act in pervasive environments characterized by frequent and unpredictable changes. In this case, policies cannot be all specified a priori to face any operative run time situation, but require continuous adjustments to allow agents to behave in a contextually appropriate manner. Current approaches to policy representation have been restrictive in many ways, as they typically follow a subject-centric model, which assigns agent permissions and obligations on the basis of agent role/identity information. However, in the new pervasive scenario the roles/identities of interacting agents may not be known a-priori and most important, may not be informative or sufficiently trustworthy. We claim that the design of policy-based agent systems for pervasive environments requires a paradigm shift from subject-centric to contextcentric policy models. This paper discusses some issues concerning the specification and enforcement of contextdriven policies and presents a novel context-based policy approach that considers context as a first-class principle to guide both policy specification and

enforcement. In this perspective, “context” explicitly appears in the specification of security policies and context changes trigger the evaluation process of applicable agent permissions and obligations.

Moon, B. M. (2002). Naturalistic Decision Making: Establishing a Naturalistic Perspective in Judgment and Decision Making Research. In In Proceedings of 19th Qualitative Analysis Conference, May 23-25, 2002, McMaster University, Hamilton, Ontario, Canada.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings NDM; Naturalistic Decision Making

Summary abstract:
Within the psychological sciences, and the specialized field of judgment and decision making in particular, a growing number of international researchers have coalesced around the concept of a movement called “naturalistic decision making (NDM).” While strongly sensing that their work stands apart from “laboratory” or “traditional decision research,” they have struggled somewhat to articulate a shared boundary between their movement and other researchers within their field. Various attempts to distinguish NDM have focused on different characteristics of the subject of study, aspects of the situation of study, and the study setting itself. None, however, have sought to draw boundaries on the basis of what it means to be a naturalist; that is, on the perspective a naturalist takes and the methodological position a naturalist stands in. This paper offers an overview of the NDM movement, highlights the attempts to establish its boundaries and critical remarks of those attempts, then discusses the naturalist perspective and methodological position. A suggestion is made that the adoption of the naturalistic perspective can serve as the common ground for the NDM community and deal effectively with the common criticisms waged against it.

Moon, B. M., Hoffman, R. R., Shattuck, L. G., Coffey, J. W., Goodman, P., Linn, R., Lang, J., & Sullivan, M. (2008). Rapid and Accurate Idea Transfer: Evaluating Concept Maps against Other Formats for the Transfer of Complex Information. In A. J. Cañas, P. Reiska, M. Åhlberg & J. D. Novak(Eds) Proceedings of the Third International Conference on Concept Mapping, Concept Mapping: Connecting Educators. Tallinn University, Estonia & Helsinki, Finland 2008.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Concept Maps (Cmaps) have proven useful for capturing and organizing knowledge, particularly of those who create the Cmaps. Their usefulness for transferring knowledge has not been as extensively researched. In business, government and military settings, slideshows (e.g., Microsoft PowerPoint) are a preferred format for presenting “complex” ideas, while the journal article remains the preferred format in academic circles. This empirical investigation compared Cmaps with other common formats of information presentation. Complex information expressed in a report about a humanitarian crisis was presented to military graduate students in four formats: journal article in traditional text, a hypertext version of the journal article, a Microsoft PowerPoint presentation, and a set of hyperlinked and resourced Cmaps. After reviewing the material, participants recreated the information and answered a set of questions to test comprehension of the material. Additionally, a preference survey was conducted with 34 professionals across military and industry domains to consider attitudes toward Cmaps for presentation. Cmaps were empirically demonstrated to be more effective than PowerPoint on key measures of knowledge transfer and rapidity in creation. They were also shown to be the preferred format for complex information presentation, when compared to PowerPoint.

Moon, B. M., Wei, S., & Cox, D. A. (2004). Cognitive Impact Metrics: Applying Macrocognition During the Design of Complex Cognitive Systems. In In Proceedings of 48th Annual Meeting of the Human Factors and Ergonomics Society. New Orleans, LA. (pp. 473-477).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Macrocognition is an emerging theoretical and methodological framework for describing cognitive work as it naturally occurs (Klein, Ross et al., 2003). It can form the basis for the design of complex cognitive systems that augment, rather than degrade, proficient performance. This paper presents a method for using macrocognition during design to anticipate how a complex cognitive system will impact cognition. We have developed a suite of metrics we call “Cognitive Impact Metrics” (CIM). Because they highlight the necessary features of and potential barriers to proficient cognitive performance, these metrics and their associated measures provide us with a framework in which we can generate predictions about where and how our system will enhance or hinder our performance. Application of CIM may be particularly useful in the design of systems where many potential applications must be culled down to a more manageable set of candidates.

Moon, I., & Carley, K. M. (2007). Modeling and Simulation of Terrorist Networks in Social and Geospatial Dimensions. IEEE Intelligent Systems: Special issue on Special issue on Social Computing.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
A simple theoretical multiagent model reasons about the criticality of terrorists and regions as terrorist interactions coevolve in geographical and social spaces.
Where we are influences who we know, and vice versa. As we move to new cities or countries, our contacts change. For instance, when a company relocates its employees, they develop new working relations with others while they perform assigned tasks. In theory, these relocations should improve company performance.1 However, performance also depends on individuals knowing who to ask about what—that is, on transactive memory.2 Moving disrupts transactive memory and the social relations by which information flows. So, the question arises whether performance can improve when social and geospatial distributions change simultaneously. Social and spatial relations evolve over time. Estimating their evolutions is important for management, command and control structures, and intelligence analysis research. By knowing future agent social and spatial distributions, an analyst can identify emergent leaders, hot spots, and organizational vulnerabilities. Historically, such estimations have depended heavily on qualitative data analyses by subject-matter experts.3 A few researchers approached the issue using multiagent models and simulation. The models addressed the complex nature of the organization and task assignments, resource distributions, or agent locations. The simulations addressed the near-term organizational changes. This research came from two perspectives: the effects of change in the social network4,5 and the effects of geospatial change.6,7 Both perspectives can project aspects of emerging organizational structure and future performance, but they can’t examine the interaction between physical and social movements. We’ve developed a simple theoretical multiagent simulation model to show how changes in the coevolution of social and geospatial dimensions affect group behavior. Our model overcomes the limitations of isolated social and spatial models (see the “Related Work in Social and Geospatial Modeling” sidebar). To illustrate the model’s potential for reasoning, we examine its implications here for a real-world terrorist network, using data extracted from open source texts. Although a full validation would require additional field data, the model’s output reveals important aspects of complex organizational evolution that apply beyond the counterterrorism domain.

Moon, I.-C., & Carley, K. M. (2007). Evolving Multi-Agent Network Structure with Organizational Learning. In In Proceedings of SpringSim'07, Norfolk, VA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Discrete event simulation, agent based social simulation, organizational learning, organization structure

Summary abstract:
Organizational structure changes over time due to various reasons, such as organizational learning, situation changes and personnel turnovers, etc. Estimating the structure changes will reflect organizational performance changes, emergent leaders, new key links, etc. This paper introduces a multi-agent model that simulates the organizational structure evolution over time. The simulated structure evolution will be driven by the organizational learning procedure that we devised. We perform virtual experiments with two distinct cases, an organization with the learning mechanism and the other one without learning. The performances of the two case organizations were examines under situation change assumptions. The organization with learning mechanism was better than the other when situation changes were predictable. We also scan the network topology changes over time, and we identified that the average distance among the nodes gets smaller as learning proceeds. This work is a preliminary effort to examine the effect of organizational learning and to formulate the evolution of organizational structures.

Moon, I.-C., & Carley, K. M. (2007). Locating Optimal Destabilization Strategies. In In Proceedings of ICCRTS. San Diego, CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Network destabilization is a critical tactic for disrupting organizations such as terrorist networks or organized crime networks. For any network, there are many possible tactics that could be used to destabilize it. For example, a set of nodes (people) could be removed or added. So could the links among the nodes. Even if we limit ourselves to node removal, there are issues which nodes to remove and when. Thus, an automated framework for the generation of the destabilization scenarios is useful, for example, in what-if scenario analysis and vulnerability analysis. We created 1024 randomly generated strategies and 1024 learning algorithm-based strategies for the destabilization of a sample terrorist network. The learning algorithm based strategies were more effective in reducing the performance of the network. Moreover, we analyzed the preference of the learning algorithm and discovered efficient tactics such as undermining the network first and isolating the knowledge sources of a network later. We believe that the presented method can be applied to other disciplines requiring a simulation and a what-if scenario generation involving network destabilization.

Moon, I.-C., & Carley, K. M. (2007). Self-Organizing Social and Spatial Networks under What-If Scenarios. In In Proceedings of AAMAS 2007. Honolulu, Hawaii.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Categories and Subject Descriptors
[Distributed Artificial Intelligence]: Multi-Agent Systems
General Terms
Algorithms, Experimentation
Keywords
Network evolution, Multi-agent system, Organizational structure

Summary abstract:
Multi-agent models have been used to simulate complex systems in many domains, In some models, the agents move in a physical/grid space and are constrained by their locations on the spatial space, e,g, Sugarscape, In others, the agents interact in a social multi-dimensional space and are bound to their knowledge and social positions, e,g,

Construct. However, many real world problems require a mixed model containing both spatial and social features, This paper introduces such a multi agent system, Construct-Spatial, which simulates agent communication and movement simultaneously, It is an extended version of Construct, which is a multi-agent social model, and its extension is based on a multi-agent grid model, Sugarscape, To understand the impact of this integration of the two spaces, we run virtual experiments and compare the output from the combined space to those from each of the two spaces, The initial analysis reveals that the integration facilitates unbalanced knowledge distribution across the agents compared to the grid-only model and limits agent network connections compared to the social network model without spatial constraints, After the comparisons, we setup what-if scenarios where we varied the type of the threats faced by network and observe their emergent behaviors, From the what-if analyses, we locate the best destabilization scenario and find the propagation of the effects from the spatial space to the social network space. We believe that this model can be a conceptual model for assessing the efficiency and the robustness of team deployments, network node distributions, sensor distributions, etc.

Moreau, L., Bradshaw, J., Breedy, M., Bunch, L., Hayes, P., Johnson, M., Kulkarni, S., Lott, J., Suri, N., & Uszok, A. (2005). Behavioural Specification of Grid Services with the KAoS Policy Language. In In Proceedings of Cluster Computing and Grid 2005 (CCGrid05), Cardiff, UK.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Complex services in Service-Oriented Architectures such as the Grid typically require to be configured in multiple ways that cannot be anticipated by service designers; we illustrate this requirement by studying the myGrid registry, a Grid Registry capable of supporting annotations of service descriptions by third-party users. Instead, services have to be conceived so that they can be configured at deployment and run time. We argue that KAoS is a powerful andflexible language that can help define such configurations. Using our registry case study, we examine the requirements that the definition of such complex configurations brings on policy languages and explain how they can be satisfied. Specifically, we use role-value maps to express constraints betweenproperty values; we introduce a notion of Policy Set with associated parameters that support constraints within a well defined scope; finally, we define a notion of Context that allows us to refer to property values that were extant in past execution environments. Essentially, these concepts allow us to add constraints to values in policy definitions, to organise policies in coherent and structure blocks, and to refer to the execution history. The paper discusses these concepts and how they are implemented in a binding ofthe KAoS policy language to the myGrid Registry.

Morison, A., Voshell, M., Roseler, A., Feil, M., Tittle, J., Tinapple, D., & Woods, D. D. (2009). Chapter 10. Integrating Diverse Feeds to Extend Human Perception into Distant Scenes. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section II. Presenting Battlefield Information to Warfighters: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
New technological capabilities create opportunities but also new challenges as people attempt to carry out even more demanding tasks in conflict and crisis situations. This chapter examines the impact of advances in sensing, networking, and robotic technologies. These capabilities allow people in remote locations to apprehend and explore aspects of the world as if they were standing in places that are too difficult, dangerous, or impossible to occupy. Investments in these technologies are predicated often on the belief that they will produce increased situation

awareness for the remote human observer. However, as prototypes are rolled out, automation surprises occur which reveal the risk of unanticipated and unintended breakdowns in awareness.

For example, urban search and rescue workers using robots to search inaccessible areas of debris found that interpreting the video feeds was a slow deliberative process instead of automatic reliable perceptual experience. It was difficult to accurately apprehend three-dimensional surface layout, the relative size/mass of objects, the robot's ability to traverse obstacles, the robot's speed, and the robot's local orientation. The robots acted as a stand-in for a remote human observer, mediating the observer's ability to perceive and act in the scene of interest (in this case, the feed was a video image from a single, forward looking camera). As a result, the remote observer is partially decoupled from many of the information-rich properties of the scene that would be available if the observer were present in that scene. Similar findings have come from other recent cases of using robots in search tasks where remote observers experience serious difficulties to understand the distant scene being traversed by a robotic system.

Based on such findings, we began a line of research to innovate new ways to bring distant feeds from robots and sensor nets into the range of human perceptual skills. The work began by exploring ways to "break the tyranny of the flat framed screen" as the default display medium in order to overcome the keyhole effect. In exploring different possibilities, we were developing possible uses of 3D (three dimensional) visualizations. In this work we found that 3D technology actually represents control of point of view and shifts in perspective. This is in contrast to the usual approach which tries to compare the impact of 2D versus 3D displays.

Other studies began to examine how the new sensing technology influenced coordination over multiple groups (connecting mUltiple perspectives) and commander decision making. In one study incident commanders viewed a video feed from a UAV as they responded, from a distance, to a simulated cascading chemical plant accident. The results showed that incident commanders over-relied on the video feed underutilizing other sources of information and missed important events embedded in the scenario.

Emerging form this work was the realization that the key leverage point to achieve high performance human-technology systems was to explicitly coordinate multiple perspectives across multiple roles and scales. Multiple potential design solutions were developed based on this insight about how to extend perception-including concepts for

• perspective folding for feeds from UGVs.
• adaptive focus based on event recognition and spatial/temporal center-surround
• perspective control (Roesler, 2005; Morison, in preparation) See

http://cseLeng.ohiostate.edu/productions/diversefeeds for demonstrations of the concepts.

In terms of human-robot interaction, extending perception concepts led to performance advantages arising from coordinating shared perspectives resulted in more efficient navigation, search, and rescue in a staged-world emergency response simulation. At a larger system scale, the challenge of synchronizing multiple perspectives over multiple roles and echelons in netcentric operations was examined using disaster response as an empirical test case.

The chapter provides a roughly historical account ofthe research on the theme of extended perception conducted within the context of the ARL ADA collaborations. It begins with reframing the distinction between two-dimensional and three-dimensional displays based on past findings on human perception. These findings illustrate that in a three-dimensional environment the fundamental opportunity afforded by the new technology is control of point-of-view.

With this insight in mind, the next section presents new design concepts to widen/overcome the keyhole typically found in HRI displays. Each of these designs leverage a three-dimensional virtual environment to coordinate perspective taking and even support multiple simultaneous perspectives. In assessing the advantage of the new display concepts in a navigation, search, and identify task, a novel metric for quantifying path complexity is introduced.

A new display concept for adaptive focus is presented within a surveillance context. This design overcomes the keyhole of a single pan-tilt-zoom (PTZ) video camera with a narrow field-of-view (FOV). Another display concept expands control of point-of-view to enable multiple people to take advantage of a single feed from single robot. The design coordinates the perspectives of a robot handler, a rescue worker, and a robot in a search and rescue task.

Included with this theme of coordinating shared perspectives, is the need to include synchronizing activity within netcentric operations. These netcentric operations include checkpoint operations in a military setting, urban fire fighting, and managing a convoy of walking wounded.

The final section introduces a theory of perspective-taking in virtual and physical environments. Perspective-taking is the process of changing the point of observation relative to a scene in order to understand the properties, objects, actors, and activities that are of interest to the observer. Supporting perspective-taking effectively is a key prerequisite to support people monitoring at a distance via sensor networks. This theory defines properties of perspective in sensor mediated experience, necessary relationships between a human and a virtual point-of-view,

and requirements for movement of the virtual point-of-view. In the subsequent section, these actionable constraints and requirements are then used to construct multiple instantiations of a perspective controller.

Morison, A. M., Woods, D. D., & Davis, J. W. (2009). How Panoramic Visualization Can Support Human Supervision of Intelligent Surveillance. In In Proceedings of 53rd Annual Meeting of the Human Factors and Ergonomics Society, San Antonio, TX.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In video-based surveillance people monitor a wide spatial area through video sensors for anomalous events related to safety and security. The size of the area, the number of video sensors, and the camera's narrow field-of-view make this a challenging cognitive task. Computer vision researchers have developed a wide range of algorithms to recognize patterns in the video stream (intelligent cameras). These advances create a challenge for human supervision of these intelligent surveillance camera networks. This paper presents a new visualization that has been developed and implemented to integrate video-based computer vision algorithms with control of pan-tilt-zoom cameras in a manner that supports the human supervisory role.

Murphy, R. R., & Woods, D. D. (2009). Beyond Asimov: The Alternative Laws of Robotics. IEEE Intelligent Systems.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Since their codifi cation in 1947 in the collection of short stories I, Robot, Isaac Asimov’s three laws of robotics have been a staple of science fi ction. Most of the stories assumed that the robot had complex perception and reasoning skills equivalent to a child and that robots were subservient to humans. Although the laws were simple and few, the stories attempted to demonstrate just how diffi cult they were to apply in various real-world situations. In most situations, although the robots usually behaved “logically,” they often failed to do the “right” thing, typically because the particular context of application required subtle adjustments of judgment on the part of the robot (for example, determining which law took priority in a given situation, or what constituted helpful or harmful behavior).

Myers, B., Malkin, R., Bett, M., Waibel, A., Bostwick, B., Miller, R. C., Yang, J., Denecke, M., Seemann, E., Zhu, J., Peck, C. H., Kong, D., Nichols, J., & Scherlis, B. (2003). Flexi-Modal and Multi-Machine User Interfaces. In In Proceedings of the Fourth IEEE International Conference on Multimodal Interfaces (ICMI’02). Pittsburgh, PA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Multi-modal interfaces, speech recognition, gesture recognition, handwriting recognition, gaze tracking, handhelds, personal digital assistants (PDAs), laser pointers, computer supported collaborative work (CSCW)

Summary abstract:
We describe our system which facilitates collaboration using multiple modalities, including speech, handwriting, gestures, gaze tracking, direct manipulation, large projected touch-sensitive displays, laser pointer tracking, regular monitors with a mouse and keyboard, and wirelessly- networked handhelds. Our system allows multiple, geographically dispersed participants to simultaneously and flexibly mix different modalities using the right interface at the right time on one or more machines. This paper discusses each of the modalities provided, how they

were integrated in the system architecture, and how the user interface enabled one or more people to flexibly use one or more devices.

Nakamura, M., & Jones, L. (2003). An Actuator for the Tactile Vest - a Torso-Based Haptic Device. In In Proceedings of 11th International Symposium on Haptic Interfaces for Virtual Environment & Teleoperator Systems. pp.333-339.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Our goal is to design a robust, versatile actuator for a Tactile Vest, a wearable device that provides haptic feedback to the torso. The technology we propose to use as the actuator for this device is Nitinol, a shape memory alloy (SMA). Nitinol is capable of generating large stresses and strains, but is small and flexible and able to fit in the thin, dynamic workspace of a vest. In experimental tests conducted on the SMA, a pulse 1 A in amplitude and 1 s in duration produced an average displacement of 3.7 mm and peak pressures about 20 times the touch threshold for the torso. These results indicate promise in using Nitinol to create a torso-based haptic device that can generate a wide range of stimuli, yet is comfortable to the point of being invisible to the user until a stimulus occurs.

Neville, K., Hoffman, R. R., Linde, C., Elm, W. C., & Fowlkes, J. (2008). The Procurement Woes Revisited. IEEE Intelligent Systems, 72-75.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
The set of people who are frustrated every day by badly designed information technology is very large. So is the set of people whose dollars pay for the badly designed technology. A conservative estimate ranges in the billions for the cost of large-scale information systems that end up collecting dust because they're not properly humancentered. Yes, billions and still counting—that's the scary part.
Within this large set of frustrated customers (see the sidebar "When Systems Development Neglects Human Considerations") is a subset whose job it is to do something about this situation. That subset includes policymakers, program managers, and systems engineers. It also includes a sub-subset comprising cognitive systems engineers, ethnographers, and many others who, in one vernacular or another, advocate human-centered computing. We must show that intelligent technologies—those designed to interact with humans or play a role in the cognitive work conducted in sociotechnical work systems—are usable, useful, and understandable.

Obradovich, J. H., Graham, J., Schneider, M., Gonzalez, C., & Harder, R. (2004). Experimentation for Envisioned Worlds: Understanding the Limitations of the Military after Action Review as Experimental Data. In In Proceedings of 48th Annual Meeting of the Human Factors and Ergonomics Society. New Orleans, LA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The research reported here was conducted to explore the efficacy of using the military After Action Review (AAR) process as a data collection methodology. During a weeklong U.S. Army experiment, we investigated, by means of a periodically administered questionnaire and an end-of-day log, the interactions participants reported having with other team members. When comparing the results of these tools, we found strong tendencies of the primacy and recency effects. These findings are important to researchers working in military command and control

experimentation settings where the AAR is a commonly used data collection mechanism. This paper identifies data collection practices that can help avoid potential difficulties when using end-of-day retrospective reports as an experimental methodology.

Obradovich, J. H., & Smith, P. J. (2003). Continuous Distributed Planning in the Army: Arriving at Design Concepts through Observational Studies. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures
observation

Summary abstract:
Coordination and collaboration across distributed teams during planning, preparation, and execution activities present many challenges to military command and control. One of these challenges is supporting distributed work during continuous planning events that occur prior to and during the execution of an operation. This paper discusses observations made during field studies of exercises and experiments conducted over the past year, as well as design concepts arising out of these observations.

Obradovich, J. H., & Smith, P. J. (2003). Design Concepts for Distributed Work Systems: An Empirical Investigation into Distributed Teams in Complex Domains. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society Conference. Denver, CO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Coordination and collaboration across distributed teams during planning and execution activities present many challenges to organizations and operations, including military command and control. With the increase in spatially and temporally distributed work teams, it is essential to achieve an understanding of how distributed work can be effectively supported. In this paper, we discuss issues surrounding distributed work systems that were gained through a series of investigations, including
(a) field studies,
(b) structured interviews,
(c) critical incident reports,
(d) participation in concept experiments, and
(e) literature reviews.
Characteristics held in common by the domains explored include the following: high cognitive complexity, distribution of the work (and associated responsibilities) among many people, distribution of data and knowledge among many people, uncertainty about how scenarios will actually play out, and geographic and temporal distribution of the participants. The results of these investigations presented in the form of case studies, and design concepts to support distributed work systems are suggested.

Ogden, W. (2009). Chapter 19. A Task-Based Evaluation Method for Embedded Machine Translation in Instant Messaging Systems. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section IV. Communicating Information across the Team: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
Cross-language instant messaging (CLlM) systems are intended to be used by groups of people who do not speak the same language but need to work together to accomplish common tasks. Such systems could help coordinate teams and facilitate communications by automatically translating text messages sent to team members. Members ofthe team would be able to read and enter messages in their own languages and still communicate with all members of the group. This could be particularly useful for many multinational civilian and military missions, where participants may not speak English fluently or at all.
In this chapter, we describe a series of user studies designed to investigate the usefulness ofthese systems for these purposes. These studies were focused on three distinct goals. First, we wanted to develop a new task-based method for evaluating the embedded machine translation (MT) technology in these systems. Previous MT evaluations have not been focused on this type of interactive application. Second, we wanted to use this method to evaluate the usefulness of MT technology for instant messaging and suggest specific improvements for this application. Finally, we wanted to conduct formative evaluations of the user interface for cross-language instant messaging to improve the user experience ofthese systems. Consequently, we examined the habitability of the system for accomplishing realistic collaborative tasks and to communicate relevant information when interacting with collaborators who speak different languages. In sum, we were interested in technical design issues of both the user interface and the MT software at the user interaction level.
In this effort to date, we have developed new paradigms for evaluating machine translation technology for purposes of collaborative communication. We have been conducting formative user testing of a translingual instant messaging system interface (TriM), developed by The MITRE Corporation to help military coalition partners to communicate using their own languages (Miller et. aI., 2001). In this paper, we will review issues of conducting task-based evaluations of embedded MT and discuss some of the results and implications for MT technology embedded in CUM. Next we use these implications to design and test an improvement to the TriM user interface. Then we describe a study to test the sensitivity of the method we have developed by comparing two Korean-English translation systems.

Olson, L., Winslett, M., Tonti, G., Seeley, N., Uszok, A., & Bradshaw, J. (2006). Trust Negotiation as an Authorization Service for Web Services. In In Proceedings of International Workshop on Security and Trust in Decentralized/Distributed Data Structures (STD3S) in conjunction with The 22nd International Conference on Data Engineering (ICDE'06). Atlanta, GA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Like other open computing environments, web services need a scalable method of determining authorized users. We present desiderata for authorization facilities for web services, and analyze potential ways of satisfying them. We propose a third-party authorization system for web services based on trust negotiation, discuss its implementation using the TrustBuilder runtime system for trust negotiation, and present performance results from a stock trading application.

Oron-Gilad, T. (2005). Interface Design: A Cognitive Systems Engineering Perspective. Interfaces for Ground and Air Military Robots: Workshop Summary. In Washington, DC: The National Academies Press. ISBN: 0-309-54919-1. http://www.nap.edu/catalog/11251.html (pp. 13-15).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In the early years of robotics and automated vehicles, the fight was against nature and not against a manifestly intelligent opponent. In this context, researchers and engineers in artificial intelligence aspired to design completely

autonomous systems. In military environments, however, where prediction and anticipation are complicated by the existence of an intelli- gent adversary, it is essential to retain human operators in the control loop.
Future military and civilian interface technologies will be influenced greatly by currently evolving autonomous and semiautonomous systems. Operators will act at times as monitors, as controllers, and as supervisors, each role putting different and new demands on their perceptual, motor, and cognitive capacities. In particular, future combat systems will require operators to control and monitor aerial and ground robotic systems and to act as part of larger teams coordinating diverse robotic systems over mul- tiple echelons. The goals for future operator control units are that they be (1) integrated into the soldier's total task environment, (2) capable of being used to monitor and control multiple systems, and (3) interchangeable, with a minimum of practice, among nonexpert soldiers. Display designers should give consideration to the trade-offs between meeting diverse opera- tional requirements and minimizing display and control requirements.
In this context, in November 2004 the National Research Council's Committee on Human Factors hosted a workshop with support from the Army Research Laboratory. The workshop addressed the challenges of op- erator control unit design from the perspectives of engineers who design these interfaces and human factors specialists who provide design guidance based on an understanding of human cognitive and physical capabilities and limitations. The workshop was focused on the operational context at the brigade level and below. Physical design issues ranged from such prob- lems as the size, resolution, and control constraints for small infantry- carried operator control units to the impact of motion for an operator con- trol unit mounted on large armored vehicles. Cognitive requirements re- lated to design issues include the need to support common situation awareness, multitasking, and teaming across multiple echelons. The major goal of the workshop was to identify the most important human-related research and design issues from both the engineering and human factors perspectives and to develop a list of lessons learned and fruitful research directions.
The workshop planning committee was composed of three members of the National Research Council's Committee on Human Factors—Peter Hancock (workshop chair), University of Central Florida, John Lee, Uni- versity of Iowa, and Joel Warm, University of Cincinnati. This committee was responsible for organizing the workshop and suggesting topics and pre- senters. Leading engineers and human factors researchers were chosen based on their work on human-robotic interface design.
The specific objectives, introduced at the workshop by Michael Barnes of the Army Research Laboratory, included:
• Examining scalable interfaces in terms of specialized requirements, 3-D displays, multimodal displays, handheld versus mounted control units, operational constraints, and common look and feel.
• Summarizing "what we know" and "what we need to know" as a precursor for design guidelines.
• Identifying research areas ripe for exploitation.
It is evident from the presentations and discussions that took place throughout the workshop that work on scalability is in its infancy. Rather than presenting definitive design solutions, presentations focused on such research topics as span of control, communication paradigms, multitasking, levels of detail, and size of display or control units. These topics represent different elements that contribute to an overall understanding of interface scalability issues.

Pantaleev, A., & Josephson, J. (2006). Higher-Level Fusion for Military Operations Based on Abductive Inference: Proof of Principle. In The International Society for Optical Engineering (SPIE) Defense and Security Symposium, Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings abduction, abductive inference, best-explanation reasoning, multisource information fusion, multisensor fusion, higher-level fusion, priority intelligence requirements, PIR, JDL level 2, JDL level 3

Summary abstract:
The ability of contemporary military commanders to estimate and understand complicated situations already suffers from information overload, and the situation can only grow worse. We describe a prototype application that uses abductive inferencing to fuse information from multiple sensors to evaluate the evidence for higher-level hypotheses that are close to the levels of abstraction needed for decision making (approximately JDL levels 2 and 3). Abductive inference (abduction, inference to the best explanation) is a pattern of reasoning that occurs naturally in diverse settings such as medical diagnosis, criminal investigations, scientific theory formation, and military intelligence analysis. Because abduction is part of common-sense reasoning, implementations of it can produce reasoning traces that are very human understandable. Automated abductive inferencing can be deployed to augment human

reasoning, taking advantage of computation to process large amounts of information, and to bypass limits to human attention and short-term memory.
We illustrate the workings of the prototype system by describing an example of its use for small-unit military operations in an urban setting. Knowledge was encoded as it might be captured prior to engagement from a standard military decision making process (MDMP) and analysis of commander's priority intelligence requirements (PIR). The system is able to reasonably estimate the evidence for higher-level hypotheses based on information from mUltiple sensors. Its inference processes can be examined closely to verifY correctness. Decision makers can override conclusions at any level and changes will propagate appropriately.

Pantaleev, A., & Josephson, J. (2007). Prospects for Dynamic ISR Tasking and Interpretation Based on Standing Orders to Sensor Networks. In In Proceedings of Conference on Multisensor, Multisource Information Fusion: Architectures, Algorithms, and Applications, part of The International Society for Optical Engineering (SPIE) Defense and Security Symposium. 25th Army Science Conference, Orlando, FL., and Conference on Multisensor, Multisource Information Fusion: Architectures, Algorithms, and Applications, part of The International Society for Optical Engineering (SPIE) Defense and Security Symposium.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings standing orders, PIRs, automated fusion, sensor networks, multisensor fusion

Summary abstract:
This research is intended to contribute to the development of automated and human-in-the-loop systems for higher level fusion to respond to the information requirements of command decision making. In tactical situations with short time constraints, the analysis of information requirements may take place in advance for certain classes of problems, and provided to commanders and their staff as part of the control and communications systems that come with sensor networks. In particular, it may be possible that certain standing orders can assume the role of Priority Intelligence Requirements. Standing orders to a sensor network are analogous to standing orders to Soldiers. Trained Soldiers presumably don't need to be told to report contact with hostiles, for example, or to report any sighting of civilians with weapons. Such standing orders define design goals and engineering requirements for sensor networks and their control and inference systems. Since such standing orders can be defined in advance for a class of situations, they minimize the need for situation-specific human analysis. Thus, standing orders should be able to drive automatic control of some network functions, automated fusion of sensor reports, and automated dissemination of fused information. We define example standing orders, and outline an algorithm for responding to one of them based on our experience in the field of multisensor fusion.

Park, S., & Rothrock, L. (2008). Systematic Analysis of Framing Bias in Missile Defense: Implications toward Visualization Design. European Journal of Operational Research Volume 182, Issue 3, Pages 1383-1398.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Decision analysis; OR in military; Utility theory

Summary abstract:
This paper examines the effects of framing on decision making in a homeland missile defense context across three tasks of varying complexity. Mathematically, each task was modeled as abstractions from a common resource allocation task. Logically, therefore, the effects of framing on human subjects should have been consistent across all the tasks. In the first experiment, a simple lottery was used to determine risk postures in a single-attribute case of missile defense. Results showed that, consistent with Prospect Theory, positive framing promotes risk-averse behavior whereas negative framing promotes risk-seeking behavior. In the second experiment, we used the Analytic Hierarchy Process to determine subject rankings in a multi-attribute case of missile defense. Results suggest that subjects' performances under positive framing were significantly better than performances under negative framing.

In the third experiment, we used a human-in-the-loop simulation to elicit human decisions in a missile defense resource allocation task. In comparison to the other experiments, the framing effect in the third experiment was diminished. We submit that decision biases detected in a simple choice task cannot be assumed to carry over to tasks of greater complexity even if the underlying mathematical formulation for all the tasks is the same. Moreover, we submit that the design of the graphical interface has a greater influence on human judgment bias than framing in tasks of higher complexity.

Patterson, E. S., Schweikhart, S., Anders, S., & Render, M. L. (2007). Towards a Functional Model of Quality Improvement Collaboratives. In In Proceedings of 51st Annual Meeting of the Human Factors and Ergonomics Society. Baltimore, MD.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Quality improvement collaboratives (QIC) are widely used for seeking improvements in healthcare quality and safety. Nevertheless, the effectiveness of QICs is variable. In order to support research that identifies critical elements in running a successful collaborative, we fill a conceptual gap by moving towards a functional model of QICs. Specifically, we define how QICs are distinct from traditional quality improvement teams, conceptualize how primary and secondary functions are accomplished in a means-ends framework, and illustrate how the functions are dynamically accomplished in a series of meetings by nested teams within a collaborative. Finally, we discuss distinctions among QICs.

Patterson, E. S., Woods, D. D., Cook, R. I., & Render, M. L. (2005). Collaborative Cross-Checking to Enhance Resilience. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
There has been a longstanding consensus that supporting error detection and recovery processes is critical for very high safety levels because it increases system resilience. System resilience is defined in Resilience Engineering as successful adaptation to variations, changes, and surprises by organizations, groups, or individuals. Cross-checking is a critical component of resilience because it can enable detection of erroneous assessments or actions while negative consequences can be mitigated or eliminated. Prior studies suggest that cross-checking where an additional human with a fresh perspective breaks fixations may be an effective strategy. Nevertheless, collaborative cross-checking remains a somewhat murky concept. In this paper, we describe in detail three healthcare incidents where collaborative cross-checking played a key role. Emerging patterns that provide opportunities for follow-on research are discussed.

Pazuchanics, S. L. (2004). The Effect of Combining Monaural Cues to Distance. In In Proceedings of 48th Annual Meeting of the Human Factors and Ergonomics Society. New Orleans, LA. (pp. 1832-1879).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The degree to which distance can be perceived depends on combinations of distance cues that are inherently ambiguous in isolation. Previous research on combining distance cues has focused on static monocular cues and has shown an additive relation. The present experiment was designed to examine how people integrate monaural cues (loudness, delay of reception from initiation, and frequency attenuation) to perceive distance. Monaural distance information was presented to participants using desktop computers and headphones. A general linear model (GLM) analysis revealed that monaural cues, much like visual cues, are combined linearly to form a percept of distance, but

with greater weighting given to loudness. Thus, designers of spatial displays that might be used in conditions of poor visibility could supply auditory cues for distance information. Additionally, this paper could be seen as a step along the way in understanding how people integrate multiple sources of information to perceive distance.

Pazuchanics, S. L. (2006). The Effects of Camera Perspective and Field of View on Performance in Teleoperated Navigation. In In Proceedings of 50th Annual Meeting of the Human Factors and Ergonomics Society. San Francisco CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Directly teleoperated uninhabited ground vehicles (UGVs) can grant field teams access to places and information previously unavailable. Despite their capability, the video from these vehicles can make teleoperated navigation difficult by cutting out valuable information about the spatial context around the UGV. Typically, UGV cameras provide their operators with a very narrow, “soda straw” field of view (FOV) and a first-person camera perspective. The present research investigated two methods for providing an operator with additional contextual information: widening the FOV and capturing a third-person perspective of the vehicle in its environment. The results indicate that the additional information provided by either method can facilitate aspects of navigation performance. Of the two methods, widening the FOV produced the greatest performance benefit in our task. However, if the FOV cannot be widened, the results suggest that capturing a third-person perspective may facilitate certain aspects of navigation. Finally, the benefits associated with each method were found to be additive. This result suggests that ideal video displays may incorporate both methods, but further research is necessary to understand how the specific information provided by each method impacts the many types of tasks involved in teleoperated navigation.

Pazuchanics, S. L., Chadwick, R. A., Sapp, M. V., & Gillan, D. J. (2010). Chapter 6. Robots in Space and Time: The Role of Object, Motion and Spatial Perception in the Control and Monitoring of UGVs. In M. Barnes and F. Jentsch (Eds.), Human-Robot Interactions in Future Military Operations: New Mexico State University.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section
ROBOTS IN SPACE AND TIME

Summary abstract:
The role of object, motion and spatial perception in the control and monitoring of UGVs
Uninhabited ground vehicles (UGVs) have the potential to expand human presence and intent across space and time (Riley, Murphy, and Endsley, 2006). Through the use of cameras, microphones, grapplers, and basic vehicle platforms, UGVs can grant human operators the basic abilities to “see,” “manipulate,” and “move through” off-site environments. Building on these basic abilities, UGVs can be applied to perform any number of complicated tasks remotely in environments ill-suited for humans. Because of this, UGVs have been increasingly incorporated into a variety of dangerous task domains including: urban search and rescue (USAR), explosive ordinance disposal (EOD), military operations in urban terrain (MOUT) and space exploration.
Although the potential to perform a number of complicated tasks remotely is certainly appealing, success in such operations is largely reliant on a human’s ability to control a UGV’s actions and to monitor the stream of data the vehicle provides about its environment throughout the course of its operation. Controlling a UGV often involves directing the vehicle’s course across a remotely-located space (i.e. course control activities), and/or directing how the vehicle manipulates objects using devices such as a grappler (i.e. manipulation control activities). Monitoring a UGV involves actively surveying the UGV’s environment over the span of its operation, often via a video camera, to determine the presence, motion and location of objects of interest as well as the UGV itself (i.e. monitoring activities). While some systems automate control and monitoring activities, most systems in current use require a “human in the loop” for supervision and guidance – a situation unlikely to change (Fong and Thorpe, 2001).

Despite the importance of human control and monitoring for successful remote operation, these activities remain notoriously difficult across different task domains. Course control tends to be problematic. For example, avoiding obstacles in a simulated USAR scenario was observed as a common difficulty across different teams and systems during the 2002 American Association for Artificial Intelligence Robot Rescue Competition (Yanco, Drury and Scholtz, 2004). Manipulation control is also difficult. Extensive training and workload are necessary to use grappler arms to move dangerous objects in current EOD and firefighting systems (Lundburg 2007). Monitoring, too, can be met with considerable difficulty. In USAR scenarios, multiple human operators are often needed to monitor video for objects of interest within the environment and to determine their location (Riley and Endsley, 2004).
To remedy control and monitoring problems such as these, the role that critical perceptual processes play in guiding everyday control and monitoring activities needs to be considered (Tittle, Roesler and Woods, 2002; Chen, Haas, Pillalamarri, and Jacobson, 2006; Chen, Haas and Barnes, 2007). When humans control and monitor their own actions across space and time, fundamental perceptual processes including, but certainly not limited to, object recognition, motion awareness and the formation of global spatial comprehension allow these activities to be completed with some degree of skill. By identifying and addressing the types of “remote perception problems” (Tittle et al, 2002) human operators experience in UGV operation scenarios and the user-interface and environmental contributors to these problems, controlling and monitoring these vehicles can be facilitated. To assist in this endeavor, this chapter describes the roles that object recognition, motion awareness, and global spatial comprehension play in both everyday and UGV control and monitoring activities. It describes the difficulties UGV operators encounter when remotely engaged in each of these perceptual processes and discusses the potential factors that contribute to these difficulties. Finally, the chapter provides guidance for supporting and enhancing remote perception and proposes suggestions for future research.

Pazuchanics, S. L., & Gillan, D. J. (2003). The Effect of Combining Monaural Cues to Depth within and across Modalities. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making

Summary abstract:
The degree to which depth can be perceived depends on the presence of depth cues, including monocular and monaural depth cues. These cues are ambiguous by nature. Any individual cue might be interpreted as providing depth information or some other sort of information about the environment. Two experiments were designed to examine how people integrate monocular and monaural cues to gain a perception of distance by, first, exploring how monaural cues affect this perception and, second, exploring how both monaural and monocular cues affect this perception. Monaural and monocular depth information was presented to participants using desktop computers and headphones. A general linear model (GLM) analysis revealed that monaural cues, on their own, are combined linearly to form a percept of depth. However, when monaural and monocular information were presented simultaneously, visual cue dominance occurs in which monocular cue information overrides that provided by monaural cues. This information can be used to improve the interpretability of apparent depth displays.

Pazuchanics, S. L., & Gillan, D. J. (2005). Displaying Distance in Computer Systems: A Lesson from Two-Dimensional Works of Art. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Virtual depth displays depend on static, monocular cues. Models of integrating monocular cues may be continuous (additive) or discontinuous. Previous research using simple displays and a small number of cues supported continuous cue integration. The present research is designed to expand the understanding of how the visual system integrates information from multiple pictorial cues by investigating combinations

of one to ten pictorial cues in visually-rich, two-dimensional displays (paintings and photographs). Participants estimated depth in target paintings and photographs relative to a standard two dimensional display. Certain results suggest that the visual system integrates cues in a largely additive way, but after a number of cues are present there may be an additional boost in perceived depth resulting in a best-fitting discontinuous model of cue combination. However, this discontinuous effect may be due to design decisions made by the painters rather than exclusively to the perceptual processes of the viewers. Analyses of these design decisions provide lessons for the design of two-dimensional displays.

Peffer, J. E., Tittle, J. S., Gualtieri, J. W., Elm, W. C., Voshell, M., Prue, B., & Woods, D. D. (2008). How Costly Is Your C2 Coordination? Assessing the Coordination Requirements within Command and Control. In In Proceedings of 13th International Command and Control Research and Technology Symposium: C2 for Complex Endeavors. Bellevue, WA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
C2 Metrics and Assessment; Cognitive and Social Issues; C2 Concepts, Theory and Policy

Summary abstract:
As the size and complexity of Command and Control (C2) domains continues to increase, new approaches (e.g., Net-Centric Warfare) have been proposed to dynamically recruit additional resources by creating distributed teams to handle rapidly changing situations. Although the added flexibility does have the potential to create C2 structures capable of responding to a wide array of challenges, this addition of distributed team members creates new coordination costs. The performance of the C2 team is impacted by the additional cognitive demands now required for team coordination and collaboration, in addition to the fundamental decisions of the domain.
Recently, Voshell, Woods, Prue, and Fern (2007) have proposed Coordination Loops as a means of specifying the requirements for supporting distributed cognitive work. This paper will detail an extension of Coordination Loops from a functional perspective, to understand the relationship between coordination needs and the stress they place on specific decisions within a work domain (e.g. Emergency Management). By mapping organizationally defined roles onto a functional, goal-means decomposition of the domain, both the inherent information needs of the domain and the additional information needs for coordination can be understood in the same context. This approach yielded unique insights were gathered about coordination assessment and design to reduce cognitive and coordination workload.

Pezdek, K., Deffenbacher, K. A., Lam, S., & Hoffman, R. R. (2006). Chapter 11. Cognitive Psychology: Applications and Careers. In S. Donaldson, D. Berger, & K. Pezdek (Eds.), Applied Psychology: New Frontiers and Rewarding Careers (pp. 221-241). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Psychological research is often conceptualized as being either basic research or applied research. Basic psychological research, usually laboratory based, is conducted to gain a scientific understanding of human behavior, often primarily for the purpose of advancing relevant theories. Applied psychological research is conducted for some additional reasons: to gain a scientific understanding of human behaviors that occur in work and everyday life, or to solve practical problems encountered in daily pursuits. In this chapter, historical and current trends in cognitive psychology research are presented to demonstrate the rich tradition of applied research in this specific field of psychological research.
Cognitive psychology is the study of human intelligence and how it works. This includes the study of thinking, reasoning, problem solving, decision making, memory, language, perception, and attention. Cognitive psychology research is well known for its strong theoretical base. Whether inductively (theory is derived from data) or

deductively (the theory comes first and the empirical test follows), cognitive psychology research is strongly linked to theory. However, it is an oversimplification to categorize cognitive psychology as basic research, from which few applications have been derived. Furthermore, it is a fact that many cognitive psychologists work in industry, educational settings, and the private sector (e.g., human factors consulting firms). From psychology's early days to the present, there has been an interest in applications. The first President of the American Psychological Association (APA), G. Stanley Hall, conducted applied research, especially on topics in human development. Few realize that he was also the founder of the APA journal, Journal of Applied Psychology in 1917. The rich history of research in applied cognitive psychology is reviewed in more detail by Hoffman and Deffenbacher (1992).
The primary purpose of this chapter is to dispel the myth that cognitive psychology research is primarily basic research that has little applicability to real-world problems. This chapter briefly focuses on five domains of applied cognitive psychology. Each of these is a domain in which there is a rich history of research and in which a significant number of cognitive psychologists are currently employed outside of academia. The domains to be discussed are forensic psychology, marketing and advertising, education, the military, and human factors. Within each domain, a brief history of cognitive psychology research on this topic is discussed, some of the current work on this topic is presented, and examples of careers in this field are provided.

Phillips, F. (2007). Supporting Research through the Art of Visual Storytelling. Podcast. Http://Csel.Eng.Ohio-State.Edu/Podcasts/Flip/Story.Html. In Podcast. http://csel.eng.ohio-state.edu/podcasts/flip/story.html.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Good science consists of more than analytic integration and testing of concepts. Compelling communication is needed so that the relevant ideas are not lost in the 'noise' of data, technology and cha nge. Clearly, this can work both ways- weak concepts and poor analysis can be •over-presented.' To deal with this conundrum all students of science would be well served by learning and using visual story telling skills.
As part of the Institute for Collaborative Innovation run by Ohio State University's Cognitive Systems Engineering Laboratory (CIS/E/L), Professor Phillips speaks on storyboarding as a technique to evolve narrative support and structure for analysis as well as for communication. This enhanced podcast complements on going C/S/E/L work exploring new techniques In the creative design process and animated scenario development.
Professor Flip Phillips of Skidmore has participated in the annual Institute for Collaborative Innovation as part of collaborations with C/S/E/L team members. He combines research human perception and his experience as an animation scientist and technical director at Pixar Animation Studios to innovate new forms of human-robot coordination

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Phillips, F., & Voshell, M. (2007). A Novel Metric for Evaluating Human-Robot Navigation Performance. In In Proceedings of RTA/HFM Symposium: Human Factors of Uninhabited Military Vehicles as Force Multipliers, Biarritz, France.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Categories and Subject Descriptors
H.4 [Information Systems Applications]: Miscellaneous;
D.2.8 [Software Engineering]: Metrics-complexity measures, performance rmeasures
General Terms
fractal dimension, Tortuosity, Human_Robot Coordination

Summary abstract:
It is frequently desirable to quantitatively evaluate performance in human-robot interaction. In this research, we introduce a novel use of fractal based performance measures to evaluate robot navigation. It can be difficult to use simple measurements such as path length and task timing due to large amounts of individual variability along these metrics, This shortcoming makes these measures particularly unsuitable for evaluating human/robot navigation performance in a complex environment with multiple tasks, Herein we outline a class of novel metrics for evaluating

navigation performance using fractal geometry. This class of space and time invariant metrics allows us to better analyze humau-robot exploration, interpret valuable behavioral information for analysis of movement, measure the handler/robot's search efficiency, path tortuosity, and overall space utilization in relation to handler goals and overall characteristics of the environment. We present techniques for computation and empirical results from our own navigation interface studies.

Pierce, L. G. (2002). Barriers to Adaptability in a Multinational Team. In In Proceedings of 46th Annual Meeting of the Human Factors and Ergonomics Society. Baltimore, MD.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The majority of current military missions require collaboration among multiple nations. For example, the military presence established in Bosnia-Herzegovina (B-H) following the end of their civil war included participants from over 38 nations. U.S. Army forces were assigned to the headquarters element and to Multinational Division North (MND(N)). We reviewed processes of the U.S. Army force commanding MND(N) to assess the degree to which army forces were being prepared to adapt their warfighting skills to conduct multinational peacekeeping missions. Barriers to adaptability were identified in their approach to deployment training and the organization of the military headquarters. U.S. forces were not trained to work with multinational partners and multinational staff members were not integrated into staff planning processes. Methods to improve team adaptability and a framework for considering the relationship among cultural, social cognitive processes and multinational teamwork are proposed.

Pisu, P., Cantemir, C.-G., Dembski, N., Rizzoni, G., Serrao, L., Josephson, J. R., & Russellc, J. (2006). Evaluation of Powertrain Solutions for Future Tactical Truck Vehicle Systems. In The International Society for Optical Engineering (SPIE) Defense and Security Symposium, Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings military truck, hybrid powertrain, design space exploration, simulation, optimization.

Summary abstract:
The article presents the results of a large scale design space exploration for the hybridization of two off-road vehicles, part of the Future Tactical Truck System (FTTS) family: Maneuver Sustainment Vehicle (MSV) and Utility Vehicle (UV). Series hybrid architectures are examined. The objective of the paper is to illustrate a novel design methodology that allows for the choice of the optimal values of several vehicle parameters. The methodology consists in an extensive design space exploration, which involves running a large number of computer simulations with systematically varied vehicle design parameters, where each variant is paced through several different mission profiles, and multiple attributes of performance are measured. The resulting designs are filtered to choose the design tradeoffs that better satisfy the performance and fuel economy requirements. At the end, few promising vehicle configuration designs will be selected that will need additional detailed investigation including neglected metrics like ride and drivability. Several powertrain architectures have been simulated. The design parameters include the number of axles in the vehicle (2 or 3), the number of electric motors per axle (1 or 2), the type of internal combustion engine, the type and quantity of energy storage system devices (batteries, electrochemical capacitors or both together). An energy management control strategy has also been developed to provide efficiency and performance. The control parameters are tunable and have been included into the design space exploration. The results show that the internal combustion engine and the energy storage system devices are extremely important for the vehicle performance.

Plott, C. C., Endsley, M. R., & Strater, L. D. (2004). Integrating Sagat into Human Performance Models. In In Proceedings of 2004 Conference on Human Performance: Situation Awareness and Automation. Daytona Beach, FL.

An Annotated Bibliography of Studies and Reports Produced by the Advanced Decision Architectures Consortium of the Collaborative Technology Alliance from 2001 to 2010

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings Situation awareness; SAGAT; Human performance modeling

Summary abstract:
Over the last decade a number of methods for empirically assessing individual and team situation awareness in simulator and operational environments have been developed and applied. The Situation Awareness Global Assessment Technique (SAGAr) has been used across a number of operational contexts for empirically assessing situation awareness. The results of these applications have shown that SAGAT is both theoretically sound and provides a valid method for assessing situation awareness. During the same period, simulation models of human performance for assessing and predicting individual and team performance times, accuracies, and workload were also developed and applied across a wide variety of contexts. In particular, several efforts have demonstrated the predictive validity of task network models of human performance. Measures of situation awareness have only recently begun to be incorporated into these types of human perfonnance models. In this paper, we describe a method for incorporating the SAGA T scoring system into task network models of human performance. In addition, we provide a discussion of the benefits of exploring the dynamics of the situation awareness measures through the exercising of the human performance models.

Potter, S. S., Woods, D. D., Roth, E. M., Fowlkes, J., & Hoffman, R. R. (2006). Evaluating the Effectiveness of a Joint Cognitive System: Metrics, Techniques, and Frameworks. In In Proceedings of 50th Annual Meeting of the Human Factors and Ergonomics Society. San Francisco CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
An implication of Cognitive Systems Engineering is that joint cognitive systems (JCS; also known as complex socio-technical systems) need to be evaluated for its effectiveness in performing the complex cognitive work requirements. This requires using measures that go well beyond “typical” performance metrics such as the number of subtask goals achieved per person per unit of time and the corresponding simple baseline comparisons or workload assessment metrics. This JCS perspective implies that the system must be designed and evaluated from the perspective of the shift in role of the human supervisor. This imposes new types of requirements on the human operator. Previous research in CSE and our own experience has lead us to identify a set of generic JCS support requirements that apply to cognitive work by any cognitive agent or any set of cognitive agents, including teams of people and machine agents. Metrics will have to reflect such phenomena as “teamwork” or “resilience” of a JCS. This places new burdens on evaluation techniques and frameworks, since metrics should be generated from a principled approach and based on fundamental principles of interest to the designers of the JCS. An implication of the JCS perspective is that complex and cognitive systems need to be evaluated for usability, usefulness, and understandability; each of which goes well beyond raw performance. However, conceptually-grounded evaluation frameworks, corresponding operational techniques, and corresponding measures for these are limited. Therefore, in order to advance the state of the field, we have gathered a set of researchers and practitioners to present recent evaluation work to stimulate discussion.

Priest, H. A., Burke, C. S., Munim, D., & Salas, E. (2002). Understanding Team Adaptability: Initial Theoretical and Practical Considerations. In In Proceedings of 46th Annual Meeting of the Human Factors and Ergonomics Society. Baltimore, MD. (pp. 561-565).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Team adaptability is just beginning to be understood by researchers. Team training, team effectiveness, and adaptability have provided researchers with a pool of evidence that can be leveraged into meaningful team adaptability research. However, team adaptability is different from individual adaptability. Teams have processes

that individuals do not. Furthermore, team adaptability refers to more than just effective performance. The following paper identifies 2 team processes that past literature indicates is important to adaptability (feedback and shared mental models). Theoretical issues and practical training issues are examined to help determine their role in adaptive teams.

Rehak, M., Pechoucek, M. & Bradshaw, J. M. (2007). Representing Context for Multiagent Trust Modeling. In In Proceedings of 2006 IEEE/WIC/ACM International Conference on Intelligent Agent Technology. Hong Kong, .

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
We present a universal mechanism that can be combined with existing trust models to extend their capabilities towards efficient modelling of the situational (contextdependent) trust. The mechanism describes the similarity between the situations using their distance in a metric space and defines a set of reference contexts in this space to which it associates the trustfulness data. The data associated with each reference context is updated and queried with the weight that decreases with distance between the current situation and the reference context. In the presented mechanism, we use Leader-Follower clustering to place the reference contexts to be representative of the data. In an empirical test, we show that context-aware models easily outperform the general trust when the situation has an impact on partner trustfulness and that their performance and efficiency is comparable with general trust models when the trustfulness is independent of the situation. Multi-context nature of the model also expands its use towards more advanced uses, allowing policy/norm learning from at the trust model at runtime, as well as reasoning based on uncertain identities.

Riley, J., & Strater, L. (2006). Assessing Effects of Robot Control Mode on Performance and Situation Awareness in a Maze Navigation Task. In In Proceedings of 3rd Annual Workshop on Human Factors of Unmanned Aerial Vehicles, Mesa, Arizona.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Situation awareness in HRI
• Ability to complete remote tasks has improved with more sophisticated unmanned vehicles (UVs).
• UVs used to facilitate perception and project operator intent on space.
• Effective use of UVs dependent upon:
  – User skills
  – System design and capabilities
  – Knowledge that user is able to acquire for task completion
• Situation awareness (SA) is knowing what’s going on around you.
  – Endsley (1988) defines it as perception, comprehension, and projection.
  – For robotic system it’s awareness of:
    • Local environment
    • Remote environment
    • System status
    • Current task state / robot actions
    • Task requirements
    • Other team members (robots and/or humans)
  – SA critical because it is the framework for plans and action, the foundation for decision making.
Current Objective
• Look into specific aspects of the model
  – Assess effects of robot control requirements (and the addition of automation) on operator performance and SA in UV control task
    • Compare serial manual control with parallel manual control

• Compare manual control with automated control modes
– Investigate any relationships between response measures

Riley, J. M., & Endsley, M. R. (2002). Computer-Aided Decision Support: Is It What the Army Needs? In In Proceedings of 46th Annual Meeting of the Human Factors and Ergonomics Society. Baltimore, MD.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
There has been a call for computer-aided decision support in Army and other military operations as a result of the increasing pace of current and fbture warfare. These tools are expected to speed up the critical thinking process, for example in battle planning and course of action analysis, by providing users with critical information and off-loading various cognitive tasks. There is a need, however, to determine the kinds of decision tools that are best suited to Army operational needs and to consider the potential implementation issues associated with application of automated tools to complex operations. A structured approach is needed to analyze Army operations and reveal the critical information needs associated with the various positions, and to determine what is appropriate in terms of decision aiding systems. Understanding information needs and adequately designing for human integration with decision tools will be important to successfid overall system performance.

Riley, J. M., & Endsley, M. R. (2003). Supporting Planning and Situation Awareness in Army Command and Control. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society Conference. Denver, CO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The planning process is the initial basis for tactical maneuvers and combat operations. Though plans are driven by the intent of the commanding officer, the quality of plans are heavily dependent upon the level of situation awareness of officers involved in the process. To support Army planning in command and control, it is important for us to understand planning and the challenges to providing the critical information underlying it. We conducted a theoretical investigation of maneuvers planning in combat situations. We used results from goal-directed task analysis, and insights from observations of Army training exercises and experiments, to make inferences on the activities carried out in preparation for tactical maneuvers. Our goal was to identify major characteristics of the planning process in current and future Army force structures. We were also interested in identifying human factors issues associated with planning in a rapidly evolving environment, and generating computer-based design concepts to support situation awareness and decision making.

Riley, J. M., & Endsley, M. R. (2004). The Hunt for Situation Awareness: Human-Robot Interaction in Search and Rescue. In In Proceedings of 48th Annual Meeting of the Human Factors and Ergonomics Society. New Orleans, LA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Robots are gaining acceptance as team members in complex task completion, though they must be directed or closely supervised by human operators. Effective interaction between operators and robots is dependent upon the operator’s ability to develop situation awareness on the robot and environment. In teleoperation this requires the effective distribution of attention between remote activities and the local controls and interfaces. Limitations in attentional resources can limit SA on one or the other place, resulting in overall decreased system performance. We present observations made at a robot-assisted search and rescue exercise to describe common SA problems in

vehicle control. This paper focuses on human-robot interaction and the role of SA in search operations. Key SA concerns observed and discussed include difficulties in robot localization, inadequate support for team operations and shared SA, workload in the visually demanding task, and poor integration of data at the interface.

Riley, J. M., & Endsley, M. R. (2005). Situation Awareness in Hri with Collaborating Unmanned Robotic Systems. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In future Army operations, soldiers may be required to remotely operate multiple robotic vehicles and participate in collaborative tasks with these systems. The ability to acquire and maintain situation awareness in tasking and controlling robots will be critical to human-robot interaction. Understanding the critical information requirements for robotics tasks will be important, particularly when operators must work with multiple systems across aerial and ground platforms, and must perform under what will likely be varying levels of system autonomy. Here, we examine SA needs in the context of a collaborative military task involving deployment of a single UAV that is coordinating with multiple UGVs to identify “safe lanes” for advancing troops. Cognitive task analysis was conducted for the task, along with an examination of potential function allocations that may require operator multi-tasking and frequent task switching. Issues in developing and maintaining situation awareness are discussed.

Riley, J. M., Endsley, M. R., Bolstad, C. A., & Cuevas, H. M. (2006). Collaborative Planning and Situation Awareness in Army Command and Control. Ergonomics, 49(12-13), 1139-1153.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Command and control; Planning; Collaboration; Situation awareness

Summary abstract:
We conducted a theoretical investigation of a complex command and control (C2) operation—the manoeuvres planning processes in Army land-battle situations, to improve understanding of how technology can best be designed to support planning and course of action development. We drew upon results from cognitive task analyses and interviews with subject matter experts and insights gleaned from observations of Army training exercises and experiments to make inferences on the C2 activities carried out in preparation for tactical manoeuvres. In this paper, we summarize several critical human factors issues associated with planning in a rapidly evolving environment, as identified in our investigation, and describe system design concepts aimed at addressing these challenges to distributed collaborative planning of C2 activities. We conclude with implications for the application of these findings to other C2 domains.

Riley, J. M., Endsley, M. R., Jones, D. G., & Bolstad, C. A. (2003). Integrating Automation with C4isr: A User Centered Approach. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003 (pp. 175-177). College Park, MD: U.S. Army Research Laboratory.

Key Words:
Human Performance

Summary abstract:
The desire for intelligent computer aids in Army and other military operations has increased as a result of the quickening pace of current warfare and the need to dominate information to obtain tactical advantage over the

opposition force. These tools are expected to speed up the critical thinking process, for example in battle planning and course of action analysis, by providing users with timely and critical information and off-loading various cognitive tasks. There is a need, however, to determine the kinds of decision aids and automated systems that are best suited to Army operational needs. A structured approach is needed to analyze Army operations and soldier responsibilities in order to reveal the critical situation awareness requirements and to determine how to support decision making. Our initial research efforts have focused on identifying system design features and factors associated with intelligent aiding tools that might lead to effective integration between the human user and his/her computer teammate. A cognitive task analysis method was used to identify situation awareness requirements for brigade level staff officers and to develop position-tailored decision displays to support the decision making process.

Riley, J. M., & Kaber, D. B. (2001). Utility of Situation Awareness and Attention for Describing Telepresence Experiences in a Virtual Teloperation Task. In In Proceedings of International Conference on Computer-Aided Ergonomics and Safety.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The current study assessed the utility of measures of situation awareness (SA) and attention allocation for objectively describing telepresence. The concepts of SA and attention have been identified as cognitive constructs potentially underlying telepresence experiences. The motivation for this research was to establish an objective measure of telepresence and to further investigate the relationship between telepresence and teleoperation task performance. Research subjects performed a virtual demining task at varying levels of difficulty using a simulated rover equipped with mine neutralization tools. At the same time, they completed two secondary monitoring tasks. Teleoperation task performance, SA, secondary task performance (attention), and telepresence were measured during the experiment. Results demonstrated level of difficulty (LOD) effects on performance and telepresence. Regression analysis revealed LOD and attention to explain significant portions of the variance in telepresence. Correlation analyses revealed significant relationships between teleoperation task performance and subjective ratings of telepresence, as well as telepresence and SA and attention.

Riley, J. M., Kaber, D. B., & Draper, J. V. (2005). Situation Awareness and Attention Allocation Measures for Quantifying Telepresence Experiences in Teleoperation Human Factors and Ergonomics in Manufacturing, 14(1), 51-67.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
This study assessed the utility of measures of situation awareness (SA) and attention allocation for quantifying telepresence, the sense of being present at a remote site, in a teleoperation task scenario. Attention and SA have been identified as cognitive constructs potentially underlying telepresence. The motivation for this research was to establish an objective measure of telepresence and investigate the relationship between telepresence and teleoperation performance. Twenty-four research participants performed a virtual ordnance disposal task at varying levels of difficulty (LODs). The task involved locating, identifying, and disposing of virtual land mines in an outdoor environment using a simulated remote-control rover with a robotic arm. Performance, SA, and attention allocation were recorded along with subjective assessments of telepresence. Results demonstrated LOD effects on performance and telepresence. Regression analysis revealed LOD and attention to explain significant portions of the variance in telepresence. Results of the study provide further evidence that telepresence may share a relationship with performance, and that cognitive constructs, such as attention and SA, may serve as alternative, objective measures of telepresence. ©2004 Wiley Periodicals, Inc.

Riley, J. M., Murphy, R. R., & Endsley, M. R. (2006). Chapter 25. Situation Awareness in Control of Unmanned Ground Vehicles. In N.J. Cooke, H.L. Pringle, H.K. Pedersen, & O. Connor (Eds.), Human Factors of Remotely Piloted Vehicles. Series Title: Advances in Human Performance and Cognitive Engineering Research . Series Editor: Eduardo Salas, Nancy Cooke, James E. Driskell & Anders Ericsson. Amsterdam: Elsevier- JAI Press.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Robotic systems are proving to be assets in many civilian and military operations, particularly those that are poorly suited to physical insertion of human operators (e.g., exploration of collapsed structures in which areas requiring visual search are too small and/or unstable for human entry) (Murphy, 2004). In these situations, robotic entities become the remotely controlled eyes, ears, and sometimes hands, of the human operator. The robots are used to project the operator's presence and intent upon objects in the remote space. The effectiveness of human interactions with the robot system drives the overall operational performance. The quality of this human-robotic interaction (HRI) is highly dependent upon the operator's ability to develop and maintain situation awareness (SA) during performance.
An important issue in the control of remotely operated vehicles is the limitation in development of SA due to impoverished sensory information, attentional resource limits, task/environmental stressors, and system design faults. In addition, where autonomy is added to compensate for some of these problems and provide for a lower operator-to-vehicle ratio, problems associated with supervisory control can contribute to SA challenges. This chapter discusses the importance of SA and provision of SA requirements through the interface, effects of task, environmental and system factors on operator SA, and interface design issues that impede SA development during task perforrnance. Examples of SA challenges are provided in the context of robot-assisted urban search and rescue (USAR) operations and are derived from extensive experience in this environment and naturalistic observations of remote control operations.

Riley, J. M., & Strater, L. D. (2006). Effects of Robot Control Mode on Situation Awareness and Performance in a Navigation Task. In In Proceedings of 50th Annual Meeting of the Human Factors and Ergonomics Society. San Francisco CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Our ability to complete tasks in remote environments has improved with increased sophistication of robotic systems. The quality of remote task performance is driven by the quality of human interaction with robots which can be dependent upon the operator’s ability to acquire situation awareness (SA) for task completion. There are, however, often critical limitations in development of SA, which are projected to have a magnified effect when operators must task and control multiple unmanned systems. In this study, we investigated the effects the mode of robot control on operator performance and ability to develop SA while navigating two robots through two mazes. Participants were randomly assigned to groups to control the robots in serial (one after another) or in parallel (at the same time) either manually or using two types of automation. The participants also viewed a systems interface to monitor the status of the robots. Results indicate that participants under serial control produced higher SA scores, though not significantly different from SA scores observed under parallel control modes. The best navigation performance was observed under parallel control with a high level of autonomy that followed a prescribed set of navigation rules. This control mode also resulted in the lowest workload scores. Participants were better able to correctly respond to SA queries for lower level, perceptual items in the robotics task as compared to higher level comprehension and projection items. Performance in the monitoring task was found to be significantly, positively correlated to participant SA.

Riley, J. M., Strater, L. D., Chappell, S. L., Connors, E. S., & Endsley, M. R. (2010). Chapter 10. Situation Awareness in Human-Robot Interaction: Challenges and User Interface Requirements. In M. Barnes and F. Jentsch (Eds.), Human-Robot Interactions in Future Military Operations. London: Ashgate Publishing, Inc.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
In many of today's complex military and civilian domains, remotely controlled ground, aerial, sea surface, and underwater vehicles are being utilized as tools to extend the sensory and psychomotor capabilities of the human to remote environments. These unmanned robotic vehicles facilitate the projection of the operators' presence and intent upon the distant space. However, the degree to which the use of unmanned robotic systems leads to improved task performance is dependent upon not only how well the operator can task, control, and manage' the robot(s), but also upon how well the operator is able to develop and maintain an accurate understanding of the unfolding situation while interacting with the robotic system. Specifically, operators need to maintain a high level of situation awareness (SA) with regard to both changes in the environment and the current and future actions ofthe robots under their control. Indeed, studies investigating issues surrounding robot control have pointed out that most of the problems encountered during robotics navigation tasks, or other more complex tasks such as search and rescue, resulted from operators' lack of awareness during robot control (Burke et aI., 2004; Drury et aI., 2003). Difficulties such as these limit the utility of robots for enhancing task performance in remote environments.

Riley, J. M., Strater, L. D., Davis, F., Strater, S., & Faulkner, L. (2009). Situation Awareness and Team Communications in Robot Control. In In Proceedings of 53rd Annual Meeting of the Human Factors and Ergonomics Society, San Antonio, TX.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Operator performance in robotics tasks is impacted by the situation awareness (SA) that individuals or teams are able to acquire and maintain on the robot, the associated environments, and the tasks to be completed. SA can be influenced by team processes when multiple humans must work together for coordinating control of multiple robotic systems. In this study, we investigated the relationship between SA and team verbal communications in a collaborative robotics tasks involving robots under semi-autonomous control. Results indicate that the content, format, and amount of communication can significantly impact operator SA and task performance.

Riley, J. M., Strater, L. D., Sethumadhavan, A., Davis, F., Tharanathan, A., & Kokini, C. (2008). Performance and SA Effects in Collaborative Robot Control with Automation. In In Proceedings of 52nd Annual Meeting of the Human Factors and Ergonomics Society. 22-26 September 2008. New York City, NY USA. New York City, NY USA: HFES.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Human operators of robotic systems need to be able to acquire and maintain situation awareness (SA) in many domains in order to effectively task and control unmanned systems. Overall task performance is impacted by the SA that individuals or teams develop on the robot, the remote environment, and the tasks to be completed. Situation awareness can be limited by attentional resource limits, particularly when operators must operate multiple systems, some of which may be under automated functioning. In this study we investigate the effects of robot control

requirements, including robots under semi-autonomous control, in a task requiring coordination and shared control of a robotic system, on task performance and operator situation awareness.

Roesler, A., Feil, M., & Woods, D. D. (2003). Design Is Sharing Stories About the Future. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures

Summary abstract:
In design and development we create and share stories about the future of operational settings. These stories concern the impact of objects-to-be-created as a source of change in a field of practice. The beneficial changes envisioned provide grounds for recruiting investments and support for prospective organizational change. In effect the envisioned impact justifies the efforts needed to create and adopt the objects in question. However, research results gathered after the objects are introduced into fields of practice show that the stories of the future are often quite wrong. In other words, there is a gap between the envisioned impact of a new development and the actual impact and reverberations of that change. This paper analyzes the factors that make envisioning the future of technology change so fragile and uses this analysis to develop a decision support method for design as an envisioning process.

Roesler, A., Feil, M., & Woods, D. D. (2003). The Northwest Passage of Ideation: How Does Design Find What Would Be Useful? In In Proceedings of 6th International Conference on Naturalistic Decision Making. Pensacola Beach, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Naturalistic decision making began as a way to study practice in action. One of the reasons to understand the nature of practice is to become a participant in the design of new artifacts intended to support or expand expertise. Thus, the question arises how to link research results to the design process, in particular, how does the research process and results participate or influence the process of defining what would prove useful in the evolving field of practice. To pursue the above question creates a new issue to resolve – what is the nature of design to improve cognitive work? The de:cycle provides a general framework that captures basic functions in research and development as design produces new futures in an operational setting. De:cycle represents the design process as non-linear, distributed over multiple groups and with parallel cross-connections. It is built from observations of breakdowns in coordination and synchronization in design work that result in building the 'wrong system right.' Moving forward in design, the de:cycle is a synchronization tool; moving back in design it traces intent and the basis for intent–hypotheses about what would prove useful.
De:cycle is a cyclical structure based on six design functions:
1. DISTILL: Field researchers study practice and define valuable storylines moving from listening to stories of practice (through many methods) to developing scenarios of success, failure, expertise, and difficulties.
2. IDENTIFY: Analysts abstract patterns from the data gathered by the field work and establish a functional model to explain findings. The findings and concepts begin to define promising directions to search for what could prove useful. This function moves from scenarios to concepts for what would prove useful.
3. SIMULATE: Through exploration design picks up leverage points and cast design opportunities. This is a discovery process which starts to make promising directions into tangible functional prototypes. In this function, concepts become prototypes.
4. DEFINE: design now tunes the functional fidelity with considerations of feasibility to define realistic capabilities for realization. Functional prototypes become detailed in order to fit production.
5. ADJUST: Systems engineering turns the envisioned artifact into a reproduceable product which can be fielded (e.g., assuring legal, safety, and market factors).

6. COLLECT: Distributors release the product to the public. This involves its announcement, introduction timing, and integration into organizations; the handling of requests and revision. Products lead to new stories as practice modifies artifacts through use and adapts to new capabilities and complexities.
The Northwest passage refers to the Simulate function and to the Identify processes leading into it and the Defining processes following from it. Interestingly, the other functions are marked by well defined design artifacts–created in that process to document and share the activities and results. But the Northwest passage appears an ill defined space of opportunities where mysterious processes of creativity operate but there are great risks of getting lost and failing to find the route to usefulness.
New work is trying the artifacts and products that structure the Northwest passage providing landmarks to guide a creative but technically grounded process. Labels like affordances, representation design techniques, reusable design seeds, animocks refer to these new approaches. To illustrate the difficulties and opportunities of the Northwest passage, we document a design case that is currently in mid-passage. The design case is to develop a new concept for control of point of view called ViewTracks intended to help an observer understand a scene s/he can access through multiple virtual cameras. As an analytical tool the de:cycle framework helps structure the design decisions in play up to this point and as a support tool it helps re-orient the design process to overcome the tendency to get lost in this function.

Roesler, A., Tittle, J. S., & Woods, D. D. (2003). Viewtracks: The Importance of Point-of-View in the Design of 3-D Displays. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making

Summary abstract:
ViewTracks is a demonstration of design concepts that provide dynamic, user-controlled point of view as a key to utilize the expanding capabilities for 3-D virtual displays. Successful 3-D interfaces based on the ViewTracks concept will allow for multiple viewpoints (or cameras), smooth tracking across these camera tracks, and user control over camera location and movement patterns.

Roesler, A., & Woods, D. D. (2008). Chapter 8. Designing for Expertise. In H.N.J. Schifferstein and P. Hekkert (Eds.), Product Experience. Amsterdam: Elsevier.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Designers are often surprised when innovative new systems are introduced to the fi eld. Suddenly, the new products or systems encounter people, and with them practices and operations that have been established before the design of a new product was envisioned. As the new designs are fi elded, users are confronted with the new products and wonder how they afford new possibilities and how they can be integrated into current activities.
How artifacts are put to use depends in large part on the perspectives, initiatives, and inquiries of these users. The people who will engage in the application of the new products are in many instances more than users; they are practitioners of trained skills. They are professionals who contribute their knowledge to the application of the new products and systems as they utilize these in order to accomplish their goals. Practitioners utilize products and systems with purposes in mind. Do the practitioners consider a product useful? Can they use it to advance their goals? Does it make sense to them in terms of how it infl uences or changes their activity?
As designers, we have learned to study design challenges from the perspectives of the people who will put the new designs to use: How do practitioners know what to do with the new design? What are the intentions and judgments that guide operations? How do practitioners anticipate what will likely happen next as they engage in a particular

operation with a new product? How can we – as designers – design artifacts and systems that support practitioners, so that they excel in what they are already good at? How can we integrate technologies by design to support the expertise of others or to help create new forms of expert activity?

Understanding how practitioners make decisions and formulate plans for action is a prerequisite for designing systems that facilitate domain expertise in context. We will illustrate in this chapter that expertise is comprised of many factors, and relies on the training and experience of practitioners in their domain. Expertise represents a convergence of knowledge, skills, and experience that results in competence – the ability to make appropriate decisions and assessments with regard to the situations at hand.

Experts operate in a variety of domains. We fi nd them in serious domains where they act in high-stakes functions as surgeons, pilots, judges, commanders, and high-level decision makers. Many of us are experts in everyday environments, where we converge special understanding and particular skills as technicians, designers, cooks, musicians, wine connoisseurs, and athletes (Hoffman, 1992).

Can just anyone who is particularly knowledgeable in a specifi c domain of human activity be considered an expert by others who depend on the consequences of these decisions or actions? On a day-to-day basis, we use the label 'expert' both as an indicator for a high level of profi ciency, training, and knowledge that is generally associated with extended practical experience, and as a social construct, where a group of stakeholders identify those who are more expert among them.

As more radical innovations in the form of technology-intense systems, softwaredriven products, and digital services continue to transform our daily lives, being expert has acquired a new meaning. Those among us who manage to cope with novelty can learn and adapt to be able to catch up with the continuous series of iterations, updates and improvements in a continuously changing environment. In contrast we often fi nd lab researchers and developers speaking of novice and expert users; in other words, acting as if one could divide the audience of new technological artifacts into those who are in the know, and those who do not know. This has always been a distortion, as expertise is tied to a context and depends on more than just cumulative experience.

What is it that experts know and how is it relevant to design? Expertise is rooted in a particularly deep-level understanding of a domain of practice. This understanding utilizes explanations and reasoning strategies that are extracted from a conceptual model of the domain, constructed and continuously consulted, tested, and updated by the domain expert in the course of practicing in the domain by engaging in activities in order to achieve goals. The conceptual model takes the form of an abstract representation (Rappaport, 1997; Heiser and Tversky, 2005).

Briefly, a conceptual model is composed of functional and physical relationships in the domain that were identifi ed by the expert and that allow him or her to simulate what is likely to happen next (Klein and Crandall, 1995). The conceptual model assists the expert in fi nding explanations for observations. The expert has constructed this conceptual model in the course of exploring the domain along various storylines and getting feedback about the different events that follow in various situations. Conceptual models as mental representations serve as structures for reasoning strategies that utilize actual observations in the course of sense-making (Klein et al., 2006).

Design influences the acquisition of these mental conceptual models by providing external representations that infl uence how people see the world and obtain feedback about the world. Design infl uences the use of these mental conceptual models by changing the mental workload (memory and attentional loads) associated with making sense of situations and planning how to act. These external representations mediate the user's cognitive work to develop and use conceptual models to make sense of the world accessed through the external devices and displays. Research on expertise is concerned with issues that arise in the course of work with representations in real settings – where people trained to different levels of profi ciency work at tasks to different levels of skill. We will, in the following, focus on factors that determine the knowledge and performance of experts – in roles as operators of artifacts and systems, and as stakeholders that face the complexities posed by novel technology. Expert operators and decision-makers form intentions – what needs to be accomplished, how to transform these intentions into plans and actions, how to recognize disruptions to these plans, how to cope with complexities and adapt their activities to achieve goals. Note that we replace the common terminology of 'user' with the label practitioner. We use the latter term to emphasize that people are not passive recipients of products designed for them or passive rule followers. Au contraire – people actively make things into tools and adapt plans to achieve goals as conditions and environments change. Practitioners will modify unsatisfactory design, devise workarounds, or simply abandon artifacts that do not enable their purposes.

Our objective as designers is to support the work of practitioners in context by utilizing innovative technologies that are useful, usable, and easily understood. Only if designers understand the role and nature of expertise can this integration be possible and successful (Ericsson et al., 2006).

Roesler, A., Woods, D. D., & Feil, M. (2005). Inventing the Future of Cognitive Work: Navigating the 'Northwest Passage'. In W. Jonas, R. Chow, & N. Verhaag (Eds.), Design -System - Evolution: Application of Systemic and Evolutionary Approaches to Design Theory, Design Practice, Design Research and Design Education. Also Presented at the 6th International Conference of the European Academy of Design, University of the Arts. Bremen, Germany. Bremen, Germany: European Academy of Design.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section
Cognitive Systems Engineering and Design, Design Methods,
Human-Centered Design, Ideation Design, Envisioning, Broadening,
Promisingness, Perspectives on Design, Design and Technology Development,
Practice-Centered Design.

Summary abstract:
Computer scientists, engineers, managers, and practitioners make claims about how new technologies will change cognitive work-how workers in various fields of practice solve problems in analysis, fault management, control, coordination, and replanning. When systems are built and fielded based on these beliefs, the actual effects on practice, including new forms of error, are quite different from what was envisioned as users workaround complexities or exploit new capabilities (Woods and Dekker, 2000). The gap between hopes and reality in changing the face of cognitive work arises for 2 factors: (1) because claims for new technology ignore the research findings of the field of Cognitive Systems Engineering on how people cope with complexity and (2) because advocates for new technology are trapped in a narrow range of possible expressions of the new capabilities relative to the demands of cognitive work. Since design methods have not had the desired impact of guiding designing in the context of cognitive work, the voyage of discovery that should follow from insight through research has been limited. Concepts were identified, but their implementation into the world of practice calls for an extended presence of design thinking in technology application - one that is human centered, not technology oriented (Winograd and Woods, 1997; Hoffman et aI., 2002; Hoffman et aI., 2004). This research has examined how technologists envision the future of cognitive work and found a variety of oversimplifications that narrow the process of discovery (Feltovich et aI., 2004). Based on these results, the paper proposes an integration 9fmethods from Cognitive Systems Engineering and Design Innovation for finding promising directions (e.g., Winograd and Flores, 1986; Woods and Christoffersen, 2000; and Alexander, 1964; Jones, 1970 respectively). The integration, or de:cycle, coordinates three roles (and associated processes and artifacts produced through these design processes): practitioner-how they adapt to complexity, innovator-how they envision what would be useful, and technologist-how they bring the anticipated change into the world of practice.

Ross, K. G., Crandall, B., & Battaglia, D. (2003). Complex Cognition of Battle Command in the Objective Force Unit of Action (UA). In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures

Summary abstract:
Currently, when cognition is considered in the development of systems, organizations, and training, a single cognitive element is often studied in isolation and cognition is not viewed as an inter-connected flow during performance. Designs that concentrate on an isolated aspect of cognition may impede other aspects of overall cognitive performance. We have developed a level of analysis, called macro-cognition, for examining cognition in field settings to expand the assumptions about naturalistic cognition and support more robust designs. In an experiment conducted by the Battle Command Battle Lab, Fort Leavenworth, KS, we applied techniques to access and understand the general flow of cognitive functions and processes as they might occur in the envisioned Objective Force. This paper presents preliminary conclusions about the nature of macrocognition. These

observations will allow us to continue to develop methods to understand the cognitive aspects of high-quality performance in the future force.

Ross, K. G., Klein, G., Thunholm, P., Schmitt, J. F., & Baxter, H. (2003). The Recognitional Planning Model: Application for the Objective Force Unit of Action (UA). In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures, RPM

Summary abstract:
When the Objective Force is fielded, planning cycles may be significantly faster. The Military Decision Making Process (MDMP) may run into difficulties with time pressure. The Army currently relies on abbreviated MDMP strategies, but these are not codified or standardized. A Recognitional Planning Model (RPM) has been designed to capture the actual planning process, as observed during several field exercises. The RPM may have advantages for Objective Force operations, compared to the MDMP. An experiment was conducted at the Battle Command Battle Laboratory at Ft. Leavenworth to assess the feasibility of the RPM for Objective Force. A Unit of Action (UA) brigade staff was trained in the RPM and then presented with a series of missions. The commander and staff had little difficulty employing the RPM, which felt very natural to them. Some of the participants were reluctant to replace the MDMP after spending decades practicing it, but many others were excited about a chance to move into a commander-driven strategy for fast-paced operations. It was concluded that the RPM warrants additional research as a potential planning approach for the Objective Force.

Ross, M. G., & Kaelbling, L. P. (2009). Segmentation According to Natural Examples: Learning Static Segmentation from Motion Segmentation. IEEE Transactions on Pattern Analysis and Machine Intelligence, 31(4), 661-676.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Segmentation, machine learning, motion, computer vision, Markov random field.

Summary abstract:
Abstract—The Segmentation According to Natural Examples (SANE) algorithm learns to segment objects in static images from video training data. SANE uses background subtraction to find the segmentation of moving objects in videos. This provides object segmentation information for each video frame. The collection of frames and segmentations forms a training set that SANE uses to learn the image and shape properties of the observed motion boundaries. When presented with new static images, the trained model infers segmentations similar to the observed motion segmentations. SANE is a general method for learning environment-specific segmentation models. Because it can automatically generate training data from video, it can adapt to a new environment and new objects with relative ease, an advantage over untrained segmentation methods or those that require human-labeled training data. By using the local shape information in the training data, it outperforms a trained local boundary detector. Its performance is competitive with a trained top-down segmentation algorithm that uses global shape. The shape information it learns from one class of objects can assist the segmentation of other classes.

Rothrock, L., Park, S., Barnes, M. J., McDermott, P., Hutchins, S., & Gillan, D. (2004). Systematic Analysis of Risk Visualization Strategies for Homeland Defense. In In Proceedings of IEEE International Conference on Systems, Man and Cybernetics. Washington, DC. Vol 3, pp. 2083-2088.

Key Words:

ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Decision making, utility theory, analytic
hierarchy process, simulation

Summary abstract:
An approach to conduct systematic analysis of risk visualization strategies in a homeland missile defense context is presented. The approach consists of three phases which take different perspectives toward characterizing theproblems of resource management and allocation for defense against missile attacks. Decision makers in missile defense are supervisory controllers of highly automated and resource-constrained systems. Our approach is suggested as a method to assess the effectiveness of visualization strategies in a dynamic decision environment. The three phases of our approach included a test for subject utilify preferences, a test for abject multiattribute preferences using the Analytic Hierarchy Process (AHP). and a test for subject action selection using a human-in-the-loop simulation test bed. Our approach is proposed to systematically evaluate the effectiveness of multistage decision making strategies against normative solutions to address the problem of missile defense against immediate and delayed threats. The alternatives were calculated based on expected cases of lives lost as a result of attacks on defended areas. Implementation of the test bed enabled us to investigate the effect of visualization formots on decision behavior. Some preliminary results based on a pilot study will be presented.
The implications of our study extend beyond missile defense. In a worid where catastrophic loss of civilian lives is seen by same as a victoy, those entrusted with homeland security must effectively manage limited resources to combat terrorist activities. Effective visualization formats will help to promote decisions that are informed with respect to the risks and outcomes.

Saner, L. D., Bolstad, C. A., Gonzalez, C., & Cuevas, H. M. (2009). Measuring and Predicting Shared Situation Awareness in Teams. In In Proceedings of 3rd West Point Network Science Workshop, West Point, NY. Also in Journal of Cognitive Engineering and Decision Making, Volume 3, Number 3, Fall 2009, pp. 280–308. DOI 10.1518/155534309X474497 © 2009 Human Factors and Ergonomics Society.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In order to improve our understanding of situation awareness (SA) in teams performing in technologically advanced command, control, and communications (C3) operations, researchers need to develop valid approaches to assess both individual and shared SA. We investigated SA in an interdisciplinary military rescue operation training exercise. For this study, we developed procedures to measure the degree of shared SA between two team members and to improve the accuracy of their shared SA scores. We suggest that SA scores that are calculated using many existing methods may be inflated because they often fail to account for error in terms of both the amount of information that is thought to be relevant and in the accuracy of a person's knowledge of it. We calculated true SA scores that account for both of these types of error. The measures were then used to evaluate five potential predictors of shared SA. Our analysis suggested that failure to compensate for error in SA may lead to overestimation of performance in a situation. The results also revealed a significant relationship between shared SA and participants' distance from a central, joint service team, which acted as the organizational hub within the C3 structure. Shared SA was better the further away from the hub people were, which suggests that a person's role and position within an organization affects the level of shared SA that can be achieved with other individuals.

Saner, L. D., & Gonzalez, C. (2009). Naturalistic Decision Framing in Computer Mediated Scientific Exploration. In In Proceedings of 9th bi-annual International Conference on Naturalistic Decision Making.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Framing, Decision Making

Summary abstract:

This study was conducted to determine how people frame decisions naturally. Research Approach - Decision framing was analyzed in the computer mediated Mars Exploration Rover (MER) mission planning process. Outcomes of proposed actions were coded as positively or negatively framed, with rates of framing compared relative to action specificity and expertise. Findings - It was found that positive framing was preferred in general, and that increased expertise led to more balanced consideration of positive and negative outcomes. Research Limitations/Implications – This study was exploratory and experimentation is necessary to formalize the observed patterns further. Originality/Value - The findings suggest that providing decision-makers additional information about the costs of using technology may more rapidly lead to better mental representations in technology-supported decisionmaking. Take away message – Different kinds of expert behavior promote different patterns of decision framing relative to how technology is used for decision-making.

Santamaria, A., & Warwick, W. (2007). A Naturalistic Approach to Adversarial Behavior: Modeling the Prisoner's Dilemma. In In Proceedings of Sixteenth Conference on Behavioral Representations In Modeling and Simulation (BRIMS '07).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings Naturalistic Decision Making, Human Performance Modeling, Prisoner’s Dilemma

Summary abstract:
In this paper we present a model of the prisoner’s dilemma in which human-like, adversarial behaviors emerge from interactions between two naturalistic models. In the prisoner’s dilemma, like other simple two-player games, the behaviors that arises from iterated play can be surprisingly complex. We developed a model of this task using an integrated architecture, with a task network representing the decision environment and an underlying naturalistic model of decision making determining branching in the task network. Several adaptive strategies emerged in our two-player models. In addition, we captured several qualitative effects of human performance.

Santamaria, A., & Warwick, W. (2008). Modeling Probabilistic Category Learning in a Task Network Model. In In Proceedings of Seventeenth Conference on Behavior Representation and Simulation. Providence, RI SISO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings Human Performance Modeling, Task Network Modeling, Naturalistic Decision Making, Probabilistic Category Learning

Summary abstract:
Task network modeling is a powerful computational modeling tool that supports the analysis of complex systems, but it is perceived to lack cognitive fidelity. We describe an approach for adding fidelity to task network models, using a simple “naturalistic” mechanism based on multiple trace memory and reinforcement-like learning. We present a model of the Weather Prediction Task, a canonical example of probabilistic category learning and the kind of task that would be difficult to represent in a task network framework. This model successfully picked up on the statistics of its environment, differentiating among several probabilistic outcomes. This provides another example in our growing list of human performance validations of this modeling approach.

Santamaria, A., & Warwick, W. (2009). Using a Naturalistic Mechanism to Capture Cognition and Dynamic Behaviors in Task Network Models:. In Proceedings of the 18th Conference on Behavior Representation in Modeling and Simulation (BRIMS), Sundance, UT, 31 March - 2 April 2009.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings Naturalistic Decision Making, Human Performance Modeling

Summary abstract:

Over the past several years, we have developed and tested a computational implementation of recognition-primed decision making (RPD) within Micro Saint Sharp task network models. The goal of this work was to augment task network models to improve their cognitive fidelity and flexibility. Our RPD mechanism uses multiple trace memory with a simple reinforcement-based learning to pick up on the statistics of a model environment. Here we present a collection of models and validation results that include classic categorization and probabilistic category learning tasks, dynamic adversarial and control tasks, and a larger-scaled militarily-relevant task. The range of tasks we have modeled demonstrates the flexibility of our approach and what can be accomplished with simple mechanisms.

Sapp, M., & Gillan, D. J. (2004). Length and Area Estimation with Visual and Tactile Stimuli. In In Proceedings of 48th Annual Meeting of the Human Factors and Ergonomics Society. New Orleans, LA. (pp. 1875-1879).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Why do the psychophysical functions for line length (linear) and area (compressive) differ and do they differ for both the tactile and visual modalities? Experiments 1A and B examined the effects of a twodimensional perception on psychophysical functions for visual perception. Participants used magnitude estimation to judge the diameter, area, and circumference of a set of 14 circles. The psychophysical functions for diameter was approximately 1.0, for area was approximately .60, and for circumference was above 1.0, indicating that two-dimensional perception, per se, does not cause the compressive function for area. Obtaining spatial information without vision can be important for people with demanding graphically based decision-making tasks and people with visual impairments. Tactile interfaces provide an alternative way to display and obtain information. Do the tactile and visual modalities process spatial information in similar ways? Experiment 2 examined the correspondence between visual and tactile perception. Participants touched, but did not see, a series of circles. For each circle they judged diameter, area, and circumference. Psychophysical functions for diameter length, circumference length, and area of a circle estimated by tactile perception in Experiment 2 were comparable to those for visual perception.

Sapp, M. V., & Gillan, D. J. (2003). A Perceptual Paradox: Line and Area Estimation. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making

Summary abstract:
Fast and accurate quantitative judgments, which could aid decision-making in Future Combat Systems, can be made using graphical displays. Research has shown that people accurately estimate line lengths, but underestimate area. The present research investigated possible psychophysical and cognitive mechanisms for the misestimation of area. Experiments 1-3 were motivated by Cleveland's (1983) observation that a simultaneous context -- presenting multiple circles of various sizes along with a standard circle and the to-be-judged target circle -- increased the Stevens' Law exponent for area from 0.7 to 1.0. However, Experiments 1-3 failed to replicate Cleveland's (1983) results. Experiments 4A and 4B examined possible processing differences involved in making linear or area judgments. Experiment 5 looked at the effects of dimensionality on linear and area judgments. Finally, a hypothesis that estimates of circle areas involve a processing competition between a linear component and the area component of a circle was examined by reanalysis of area judgments from all six experiments using a multiple regression model, Perceived Area = a + b1 (Circumference) + b2 (Area). The results showed a stronger relation for Perceived Area and Circumference in all six experiments. This finding provides support for the hypothesis that the linear aspects of a circle are more salient than the area aspects, which causes interference when making area judgments.

Sarter, N., Ferris, T., & Hameed, S. (2009). Chapter 9. Multi-Modal Information Exchange and Dynamic Adaptation. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter:

Foundations and Technology. Section II. Presenting Battlefield Information to Warfighters: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
High levels of complexity and dynamism will characterize the battlefield of the future. It will involve a large number of human and machine agents in various locations who need to collaborate on planning and problem-solving tasks, sometimes under considerable time pressure, high risk, and uncertainty. This implies that effective information systems, i.e., the ability to collect, store, distribute, fuse, and share information, will become increasingly important. To support this need, a line of research was conducted that focused on the distribution of information across multiple media and modalities, including vision, audition, and touch. First, a computer-based simulation platform was created that supports collocated and remote synchronous multimodal communication and coordination among multiple human and machine agents. The creation of this rather unique platform was necessary to conduct controlled studies of a wide range of issues related to multimodal information processing, including modality preferences, cross modal interactions, and context-sensitive modality selection and combination. This chapter provides an overview of the main findings from this line of research and provides guidance for the design of future multimodal displays.
The battlefield of the future will be highly complex and dynamic. It will involve a large number of human and machine agents- some of them collocated, others distributed across various locations - who need to collaborate on planning and problem-solving tasks, sometimes under considerable time pressure, high risk, and uncertainty. To support these tasks, effective information systems are needed that make it easy to collect, store, distribute, fuse, and share information. With this goal in mind, a line of research was conducted that focused on the distribution of information across mUltiple media and modalities, including vision, audition, and touch. Multimodal information presentation was originally suggested by Multiple Resource Theory (MRT) as a promising means to support operators in coping with large amounts of data. MRT assumes that different sensory channels are associated with separate attentional resources. Thus, by distributing information across, modalities, resource competition should be minimized and overall processing performance should improve. In order to design effective multimodal displays, a number of important questions related to multimodal information processing were investigated as part of this line of work, including (a) users' modality preferences, (b) cross modal spatial and temporal links between vision, hearing, and touch, and (c) the design of a context-sensitive multimodal interface that is both adaptive and adaptable. The following sections will highlight some of the major activities and findings from this effort.

Sarter, N. B. (2002). Chapter 2. Multimodal Information Presentation in Support of Human-Automation Communication and Coordination. In E. Salas (Ed.), Advances in Human Performance and Cognitive Engineering Research (Vol. 2, pp. 13-35). New York, NY: JAI Press.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Designers of human-machine interfaces have focused for a long time on the development and refinement of visual and, to a more limited extent, auditory displays. Only in recent years has a significant and rapidly increasing interest in multimodal systems emerged. To a large extent, this interest was triggered by the evolution of virtual reality (VR) technologies. Multimodal interfaces have been developed that support movement through, and interaction with, these environments and thus increase the perceived immersion in virtual worlds. Multimodal technologies have been proposed for other purposes and domains as well. They involve the potential for making computing accessible to a wider range of users, including people from different age groups, with different cognitive styles, and those with

sensory or motor impairments. Multimodal interfaces play an important role in the development of VR-based training systems (such as surgical training systems for minimally invasive surgery where tactile and force feedback is needed), and they are being developed in support of mobile computing and telerobotics.

Sarter, N. B. (2005). Graded and Multimodal Interruption Cueing in Support of Preattentive Reference and Attention Management. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
A decade ago, attention management was considered by some "the least explored frontier in cognitive science and human-machine cooperation" (Woods et al., 1994). Today, at least one aspect of attention management – interruption handling – still poses a major challenge for the design of human-machine systems and computer-supported collaborative work. Successful interruption management requires that both unintentional dismissals and preemptive integrations of interruption signals are avoided (Latorella, 1999). One means of achieving this goal is to support preattentive reference, i.e., the processing of interruption signals that occurs before attentional selection. Operators need to be provided with at least partial information about the nature and cognitive requirements of a potential interruption, and this information should be presented in a way that allows for peripheral access. This paper will discuss and illustrate how currently underutilized graded and multimodal information presentation could help accomplish this goal and support various stages of the overall interruption management process.

Sarter, N. B. (2006). Multimodal Information Presentation: Design Guidance and Research Challenges. International Journal of Industrial Ergonomics (Special Issue on New Insights in Human Performance and Decision Making - Invited contribution), 36(5), 439-445.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Multimodal information presentation; Design guidance; Touch; Crossmodal links in attention; Adaptation and adaptability

Summary abstract:
Multimodal interfaces have gained considerable interest in recent years. This trend can be expected to continue as designers try to address challenges like data overload, the need for improved performance of recognition-based systems, a greater sense of immersion in virtual-reality environments, and support for time sharing and attention management in a variety of complex real-world domains. To ensure the robustness and effectiveness of multimodal interfaces, a number of design guidelines have been proposed. The present paper will review guidelines that focus on multimodal information presentation (as opposed to multimodal system input), and it will discuss important research needs in this area, including the exploration of possible uses and benefits of rarely used sensory channels (such as touch and olfaction), the consideration of crossmodal links in attention, the top–down modulation of multimodal information processing, and the need for adaptive and adaptable multimodal interfaces.

Sarter, N. B. (2007). Chapter 13. Multiple-Resource Theory as a Basis for Multimodal Interface Design: Success Stories, Qualifications, and Research Needs In Kramer, Wiegmann, & Kirlik (Eds.), Attention: From Theory to Practice.: ADA CTA.

Key Words:
ADA CTA
Advanced Decision Architectures

Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Multimodal information processing and design has emerged as J maior research topic during the past decade (e .g. , Oviatt, 2003; Sarter, 2002, 2005; Spence & Driver, J 997, 2004). This development can be explained, in part, by the recognition that most naturalistic situations involve simultaneous 1l111ltimodal input (Neisser, 1976). It also reflects the growing need for creating artificial multi modal environments and interfaces that effectively support diverse functions, such as creating a sense of immersion in virtual reality environments or supporting mul titasking and attention management in a variety of complex, data-rich domains (e.g., Brickman. Hettinge r, & Hass, 2000; Ho, Nikolic, & Sarter, 2001; Latorella, 1999; Means, Fleischman, Carpenter, Szczublewski, Dingus, & Krage, 1993; Nikolic & Sarter, 200 1; Sklar & Sarter, 1999; Woods, 1995).
To date, the design of most rnllltimodal displays appears to have been based - implicitly or explicitlyon the original version of multiple-resource theory (MRT) (e.g., Wickens, 1984). which postulated that people possess separate fixed-capacity resources for information processing that can be characterized along three dimensions: (l) the processing stage l early vs. late processing), (2) the process ing code (spatial vs. verbal information), and (3) the information modality (visual vs. auditory encoding; other sensory channels were not considered in the original version of MRT). Based on MRT, the concurrent performance of multiple ta sks should benefit to the extent that information related to these tasks is presented in different modalities and thus resource competition is reduced.
Since its original conception, Wickens and colleagues have added qualifications to several aspects of MRT (for an overview, see Wickens [2002]) . First, they emphasized that the multiple-resource model was intended primarily to predict the performance of two or more time-shared continuolls tasks (Wickens, 1991). Also, based on a review of research methods and findings, Wickens and Liu (1988) pointed out that benefits that have been observed for cross-modal time-sharing may not necessarily be the result of drawing fr0111 independent pools of central perceptual resources. Instead, peripheral sensory factors, such as visual scanning or auditory masking, may play an important role. For example, studies that carefully controlled for visual scanning did not always show performance benefits for cross-modal information presentation. Most recently, the notion of independent perceptual resources has been questioned based on a considerable body of behavioral and neurophysiological evidence that suggests extensive spatial and temporal cross-modal links and constraints on. attention, which can both enhance and limit multi modal information processing. (For an overview, see Spence and Driver [1997, 2004].)
Although the mechanisms underlying improved time-sharing with cross-modal task and information presentation continue to be a matter of research and debate, the phenomenon itself has been confirmed and exploited in a number of research and development efforts. This chapter presents examples of the successful implementation of multi modal interfaces in support of concurrent task performance and information processing. It describes additional benefits of distributing information across sensory channels, including redundancy, complementarity, and substitution. Finally, critical research needs in the area of multi modal information processing and interface design are discussed.

Sarter, N. B., Mumaw, R. J., & Wickens, C. D. (2007). Pilots' Monitoring Strategies and Performance on Automated Flight Decks: An Empirical Study Combining Behavioral and Eye-Tracking Data Human Factors, 49(3), 347-357.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Objective: The objective of the study was to examine pilots' automation monitoring strategies and performance on highly automated commercial flight decks.
Background: Aconsiderable body of research and operational experience has documented breakdowns in pilot-automation coordination on modern flight decks. These breakdowns are often considered symptoms of monitoring failures even though, to date, only limited and mostly anecdotal data exist concerning pilots' monitoring strategies and performance.

Method: Twenty experienced B-747-400 airline pilots flew a 1-hr scenario involving challenging automation-related events on a full-mission simulator. Behavioral, mental model, and eye-tracking data were collected.
Results: The findings from this study confirm that pilots monitor basic flight parameters to a much greater extent than visual indications of the automation configuration. More specifically, they frequently fail to verify manual mode selections or notice automatic mode changes. In other cases, they do not process mode annunciations in sufficient depth to understand their implications for aircraft behavior. Low system observability and gaps in pilots'understanding of complex automation modes were shown to contribute to these problems.
Conclusion: Our findings describe and explain shortcomings in pilot's automation monitoring strategies and performance based on converging behavioral, eyetracking, and mental model data. They confirm that monitoring failures are one major contributor to breakdowns in pilot-automation interaction.
Application: The findings from this research can inform the design of improved training programs and automation interfaces that support more effective system monitoring.

Sarter, N. B., Waters, M., & Ho, C.-Y. (2003). Supporting Effective Communication and Coordination on the Battlefield through Adaptive Multimodal Information Exchange. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures
observation

Summary abstract:
The battlefield of the future will involve a large number of co-located and distributed agents who need to collaborate on planning and problem-solving tasks. They sometimes need to do so under considerable time pressure and high risk. This implies that effective information systems and operations, i.e., the ability to collect, store, distribute, fuse, and share information, will become increasingly important for the success of U.S. Army operations. One promising way to achieve these goals is the distribution of information across sensory channels. Multimodal interfaces provide numerous benefits. They support an increase in bandwidth through concurrent information presentation and processing, redundancy (i.e., several modalities can be used for processing the same information), synergy or complementarity (i.e., several modalities can be used for processing different chunks of information that need to be merged), and substitution (i.e., one modality that has become temporarily or permanently unavailable is substituted with some other channel). The goal of our research is to capitalize on these affordances in an effort to design an effective and adaptive multimodal interface that assists with distributed decision-making and problem-solving in future combat operations. We will identify and evaluate the effectiveness of natural modality selection and integration patterns for various tasks and task contexts, examine strategies for managing breakdowns in multimodal communication, explore the benefits of introducing tactile cues, and address potential difficulties with the concurrent use of more than one modality, such as the modality shifting effect or crossmodal interference.

SA-Technologies. (2009). Chapter 4 - Communicate. In J. Lipnack, J. Stamps, M. Prevou, B. Veitch, & M. Hannah (Eds.), Teams of Leaders Handbook- Building Adaptive, High-Performing Interagency Teams (Vol. 1). Fort Leavenworth, Kansas: Battle Command Knowledge System (BCKS), Combined Arms Center – Knowledge (CAC-K), Combined Arms Center (CAC). http://usacac.army.mil/CAC2/bcks/ToL_Handbook.pdf.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Interagency teams, high performing teams, learning organization, leader competence, knowledge management, leader team development

Summary abstract:
Teams of Leaders (ToL) is an approach for rapidly building and effectively employing cross-boundary teams that are highly competent both in making and executing decisions and in learning and adapting together. The ToL

approach provides a deliberate methodology for forming, launching, operating, and sustaining nested leader teams and developing their capacity to work at higher performance levels in less time. The ToL approach applies and balances three key elements—information management, knowledge management, and leader teams qualities—to boost team communication and collaboration. The value of teams of leaders increases in proportion to the diversity of team members, so that the approach is especially valuable to inter-agency and coalition (and thus cross-cultural) teams.
This handbook provides a detailed explanation of both ToL theory and practice to help doctrine writers and leadership development professionals integrate ToL into professional military education and training, and it contains worksheets and tables to help practitioners form, launch, and sustain high performing teams.

Handbook Objectives – What Does this Handbook do for you?
The Teams of Leaders Handbook is produced under the auspices of Combined Arms Center-Knowledge (CAC-K) and its Battle Command Knowledge System (BCKS) component, this handbook lays out new thinking for leaders working in interagency teams. Given the complexity of 21st-century operations, the old top-down, command-and-control models of the hierarchy no longer suffice. Instead, we need more sophisticated approaches to network the force and working across boundaries to improve collaborating, team development, and building relationships, which is what this handbook sets out to do.
Our intention is to refine and mature this work with input and reflection from those who read and use the ideas presented here. Together, we will develop leaders who are situationally aware, adaptive, and proficient at working across boundaries in unpredictable situations with peers whose backgrounds may be unfamiliar.

Schoenwald, J., Trent, S., Tittle, J., & Woods, D. (2005). Scenarios as a Tool for Collaborative Envisioning: Using the Case of New Sensor Technologies for Military Urban Operations. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This paper describes the use of a collaborative envisioning tool to combine the goals of disparate communities concerning the role of new sensor technologies being deployed in Military Operations in Urban Terrain (MOUT). To do this, Cognitive Engineering intersects with the sensor development and military operations communities. Through the use of scenario-based design and the Topic Landscape tool, generic patterns provide seeds that help envision realistic futures of MOUT which are expressed in a narrative. These patterns provide insight on two levels: On one level they describe complexities inherent to all cognitive work, while on another level they provide insight about what makes MOUT difficult. The Topic Landscape is a collaborative tool that organizes information from a Cognitive Task Analysis of MOUT in many forms (text, graphics, video, etc.) from many contributors. This approach turns scenarios from a validation tool to an effective envisioning tool.

Schraagen, J. M., Klein, G., & Hoffman, R. R. (2008). Chapter 1. The Macrocognition Framework of Naturalistic Decision Making. In J.M. Schraagen, L.G. Militello, T. Ormerod, & R. Lipshitz (Eds.), Naturalistic Decision Making and Macrocognition (pp. 3-25). Aldershot, England: Ashgate Publishing, Inc.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Naturalistic Decision Making (NDM), as a community of practice, has the goal of understanding cognitive work, especially as it is performed in complex sociotechnical contexts. In recent years, the concept of "macrognition" has emerged as a new and potential umbrella term to designate the broader paradigm that underlies NOM. In addition,

the notion of macrocognition presents challenges and opportunities for both theory and empirical methodology. The present volume is a contribution to this literature, the seventh volume in the NDM series.
In this chapter we accomplish a number of things. First, we chart the history of NDM as a community of practice and then describe its stance concerning cognitive work and research methodology. Next, we chart the history of the concept of macrocognition and then show how NDM converges with it philosophically. Finally, we use these contexts to overview the chapters in this volume.

Shafto, M. G., & Hoffman, R. R. (2002). Editors. Special Issue: Human-Centered Computing at Nasa. IEEE Intelligent Systems. IEEE Intelligent Systems.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Human-centered computing, also called “human-centered systems,”
• Focuses on creating new computational devices
• Is often contrasted with the traditional approach in computer science that might be dubbed “machinecentered computing”
That statement also accurately and succinctly describes NASA’s working definition of HCC. In the last issue of Intelligent Systems, Robert Hoffman and his colleagues presented a framework encompassing the various approaches that constitute the world of HCC. This special issue examines the particular region NASA is exploring within this vast world— the working definition of HCC shaped by NASA’s mission requirements, available resources, and existing investments.

Shattuck, L. G., & Miller, N. L. (2004). A Process Tracing Approach to the Investigation of Situated Cognition. In In Proceedings of 48th Annual Meeting of the Human Factors and Ergonomics Society. New Orleans, LA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Technologists and human factors practitioners tend to approach the measurement of situation awareness from different perspectives. Technologists compare the difference between the data available in the environment with what has been detected by the sensors built into a system. Human factors practitioners focus on perception and cognition to the exclusion of the technological parts of the system. The authors propose a Dynamic Model of Situated Cognition and use it as a framework for analyzing both the technological and human aspects of a complex system. They employ a process tracing method in the analysis of a high fidelity military command and control (C2) simulation. Their results indicate that the model and the process tracing method are effective ways in which to investigate the development of situated cognition in complex systems. In addition, their results have important implications for designers of software, hardware, and training systems.

Smith, M. W., Branlat, M., Stephens, R. J., & Woods, D. D. (2008). Collaboration Support Via Analysis of Factions. In In Proceedings of NATO HFM Symposium on Adaptability on Coalition Teamwork, Copenhagen, RTO-MP-IST-999.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:

The complexity of modern military operations causes challenges with the processes of information analysis and coordination. The difficulty inherent in dealing with factions (ubiquitous in organizations and the political realm) epitomizes these challenges. Over-simplification and neglect of distinctions and alternatives are risks in the analysis of complex phenomena. Coordination with multiple agents is a method for performing complex work in general and in particular for mitigating the cognitive challenges of analysis of complex phenomena. However, lack of common ground between agents hampers coordination, especially in unpredictable and ambiguous situations. We propose a concept for an analytic support tool based on organizing representations in a framework designed to foster exploration, preventing individual analysts from overly narrow and reductive analysis. As a collaborative tool, it can serve as a virtual open workspace, mitigating shortages in common ground by allowing analysts to be informed by one another's explorations in the framework.

Smith, M. W., Patterson, E. S., Zelik, D., & Woods, D. D. (2007). Faction Display: Visualizing the Spectrum of Risk Estimates in a Terrorist Attack. In In Proceedings of K.Mosier & U. Fischer (Eds.), Proceedings of the Eighth International Conference on Naturalistic Decision Making.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Information analysis, visualization, bias, intelligence analysis, fixation, representation aiding

Summary abstract:
Detecting biased information, and deriving an accurate assessment of issues or situations from a pool of information representing multiple factions, are challenges for which intelligence analysts have developed strategies. These include researching sources, submitting products for peer review, explicitly contrasting pro vs. con positions, and comparing predictions along a spectrum of optimism/pessimism. We explore the concept of a Faction Display as a means to use visualization to support awareness of the location of a source along a spectrum of opinion. It can be used to place estimates or other assessments in the context of the source's position among the set of factions in play. The Faction Display concept is illustrated as a "design seed" placed within the context of a safety analysis case study; the concept displays relative estimates for safe distances from Liquefied Natural Gas (LNG) pool fires resulting from a terrorist attack.

Smith, P., Bower, J., & Spencer, A. (2009). Chapter 23. Asynchronous Communication of Army Operations Orders. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section IV. Communicating Information across the Team: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
The focus of this research is on the support of asynchronous communication of plans and plan modifications among military units. The need to better support asynchronous communication in the military is evident, especially given the increasingly distributed battlefield expected in the U.S. Army of the future. In such a distributed battlefield, the commanders and planners of operations will not be colocated and, because of time constraints, will at times require asynchronous communication. This increased reliance on distributed responsibility also places more emphasis on individual responsibility to make local decisions, thus making shared situation awareness and shared understanding of intent even more important.
In the following, two empirical studies are discussed that look at issues associated with the communication of Army operations orders and taskings. In the first experiment, 46 ROTC cadets each received a company operations order, and based on that were required to write a platoon operations order followed by two recall questions. Half of the cadets received the company operations order in a conventional text format that included a static map overlay. The

other half received the same operations order, but with 4 subsections presented with attached multi-media presentations that included synchronized animation and voice narration. The group that viewed the multimedia presentation accurately recalled mission critical information 26% more often.
In the second study, a formative evaluation was completed making use of a multimedia communications tool designed to support and study asynchronous communication. While participating in a joint forces exercise, ten captains, majors, and colonels (4 soldiers from the United States, 2 from Canada, 2 from France, 1 from Israel and 1 from Germany) had the option of using this multimedia communication tool whenever they felt it would help them to communicate information to commanders in other units. They created a total of 15 messages. Two of the messages consisted of one-way communications. The remaining 13 were asynchronous dialogs. In these messages, the officers:
• Made extensive use of pointing, drawing and embedded written notes.
• Used these asynchronous dialogs to detect and repair misconceptions that arose from live face-to-face briefings (6/13 dialogs).
• Used these asynchronous dialogs to share expertise while developing a plan (13/13 dialogs).

Stanard, T., Lewis, W. R., Cox, D. A., Malek, D. A., Klein, J., & Matz, R. (2004). An Exploratory Qualitative Study of Computer Network Attacker Cognition. In In Proceedings of 48th Annual Meeting of the Human Factors and Ergonomics Society. New Orleans. LA. (pp. 401-405).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Many computer network defenders do not know how malicious hackers think and act during a network (McCloskey & Chrenka, 2001). To study attacker cognition, experienced hackers were recruited to attack a Windows 2000 network and pursue three goals: Deface the website, steal (faux) credit card numbers, and read email. Participants wrote a report of what they did, and a post-attack cognitive task analysis interview was conducted. Logs were also captured on the network including firewall, snort IDS, and Microsoft applications (IIS, SQL, Exchange). An Attacker Cognition Model based on data collected from five participants was created. The model has two basic properties: It describes the cognitive steps followed by an attacker, and describes several passes through these steps that the attacker follows as s/he penetrates several layers deep into a network. Future research using smaller sample sizes and multiple studies using the same participants is encouraged.

Stansifer, C., Bennett, K. B., Talcott, C., Martinez, S., & Shattuck, L. (2001). Digital Interfaces for Army Tactical Operations. In In Proceedings of 45th Annual Meeting of the Human Factors and Ergonomics Society. Minneapolis, MN.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Timely and accurate decisions in the Army domain are directly linked to the commander's ability to assess the battlefield. The Army has developed the Force XXI Battle Command Brigade and Below (FBCB2) interface to be used in mobile platforms to provide commanders with immediate access to critical information. Fig. I shows a version of this interface. The demonstration will illustrate a portion of the interface that was simulated for presentation of friendly forces information.

Stefanelli, C., Tortonesi, M., Carvalho, M., and Suri, N. (2008). Network Conditions Monitoring in the Mockets Communications Framework. In In Proceedings of 2007 IEEE Military Communications Conference (MILCOM 2007)/ Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Communication between mobile devices in the MANET scenario exhibits significant reliability and performance problems. Traditional communication infrastructures designed for wired networks are not well suited for MANETs because they masquerade network level conditions. In the MANET scenario, instead, there is the need to expose current network conditions to applications, enabling them to adapt their behavior to changes in the quality of the communication links. In the context of a MANET-oriented communication framework (called Mockets), this paper presents a network conditions monitoring component which provides applications with timely and accurate information about communication channel characteristics. In particular, the paper focuses on the measurement of latency, obtained via Round Trip Time measurement, for which it presents three different algorithms. The experimental results show the performances of the different algorithms in a MANET-like emulation environment.

Stefanelli, C., Tortonesi, M., Benvegnu, E., and Suri, N. (2008). Session Mobility in the Mockets Communication Middleware. In In Proceedings of IEEE Symposium on Computers and Communications (ISCC 2008), Marrakech, Morocco.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Taking advantage of the benefits of modern networking, a growing number of users are exhibiting mobile behavior. As they roam between different network localities, they access the Internet and the Web exploiting both wired and wireless communications and using several heterogeneous devices. Mobile users want to access their subscribed services anywhere, anytime, and want to preserve their currently opened service sessions as they roam between different network localities or switch between different devices. Mobile users' requirements call for novel middlewares to provide support for mobility on top of the traditional Internet infrastructure. In this context, we have developed Mockets, a communication middleware specifically designed to address the challenges ofwireless networks and mobile computing. In particular, Mockets supports session mobility in terms ofseamless handover for preservation ofend-toend connectivity in spite of node mobility, automatic detection and exploitation of best available connectivity, and migration of service session endpoints from one node to another.

Strater, L., Scielzo, S., Lenox-Tinsley, M., Bolstad, C. A., Cuevas, H. M., & Endsley, M. (2009). Chapter 20. Tools to Support Ad Hoc Teams. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section IV. Communicating Information across the Team: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
Future Force operations rely on rapidly form,ing ad hoc teams that are mobile, versatile, and distributed in time, space, and purpose, and can bring to bear multiple perspectives on a problem. Members are convened for a specific purpose and chosen primarily for their expertise, drawing from multiple Army specialties and echelons as well as Joint Forces or multinational entities. Consequently, team members often have different backgrounds and experiences, with few shared experiences at the onset of their mission. The unique nature of these teams, therefore, poses significant challenges to both military commanders and team members who must rely on one another for critical information to quickly develop sufficient Team and Shared situation awareness (SA) for decision making and achieving operational goals.

Strater, L. D., Cuevas, H. M., Connors, E. S., Ungvarsky, D. M., & Endsley, M. R. (2008). Situation Awareness and Collaborative Tool Usage in Ad Hoc Command and Control Teams. In In Proceedings of 52nd Annual Meeting of the Human Factors and Ergonomics Society. 22-26 September 2008. New York City, NY USA. New York City, NY USA: HFES.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This research details findings from Urban Resolve, a large-scale Joint Forces research effort to investigate the impacts of technological solutions on situation awareness (SA) and decision making in ad hoc teams in a military command and control environment. The investigation was conducted using personnel acting as the Joint Force Land Component Command (JFLCC) and supporting Brigade-level staff stationed at Ft. Leavenworth in support of the higher headquarters at the Joint Task Force (JTF) in an urban combat and stability scenario. In the study, participants rated face-to-face communication highest for both routine and critical communications. The tool rated most effective for the development of situation awareness changed across study sessions, with chat in chatroom rated highest in the first and last session, and shared map/shared products folder rated highest in the second session. Results are discussed in the context of developing tools to support shared SA and temporal team performance in ad hoc teams.

Strater, L. D., Faulkner, L. A., Hyatt, J. R., & Endsley, M. R. (2006). Supporting Situation Awareness under Data Overload in Command and Control Visualizations. In In Proceedings of International Ergonomics Association 2006 Congress, Maastricht, Netherlands.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings experimental study, Situation Awareness, cognition, human computer interaction, usability, Command and Control

Summary abstract:
Overcoming information overload is a central challenge for supporting information dense environments, such as military operations, some process control systems, and real-time data analysis tasks. This paper describes a study which evaluated concepts for supporting military personnel's ability to quickly assess needed information in very cluttered Common Operating Picture (COP) displays. The effort focused on the presentation of four possible unit representations on a digitized COP based on ethnographic observations of the way in which Army officers seek to deal with the proliferation of large, overlapping battlespace objects on dense displays. Sixteen U.S. Army Reserve Officer Training Corps (ROTC) cadets monitored a 28 minute simulation that depicted a developing military advance. Cadets viewed each of the four modalities with presentation order counterbalanced between subjects using a Latin squares design. For each modality, cadets responded to a rapid battery of questions about their SA using the Situation Awareness Global Assessment Technique (SAGAT). At the end of the study, participants completed a subjective questionnaire about their representation preferences. While participants prefer current MilSTD 2525B representations, objective SA measures do not support the superiority of this representation.

Strater, L. D., Riley, J. M., Faulkner, L. A., Hyatt, J. R., & Endsley, M. R. (2006). Effect of Display Icon Modality on Situation Awareness. In In Proceedings of 50th Annual Meeting of the Human Factors and Ergonomics Society. San Francisco CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The present study investigated the effectiveness of different icon modalities in supporting situation awareness (SA) when using a densely populated battlefield COP. The MilSTD 2525B symbology was compared to modified versions of this symbology that were either miniature or proportional, and the U.S. Army Research Lab's blobology concepts. ROTC cadets viewed a simulated military advance that displayed each of the four representation

modalities with presentation order counterbalanced. At the end of each segment, cadets responded to a rapid battery of questions about their SA using the Situation Awareness Global Assessment Technique (SAGAT). Participants also evaluated the different icon modalities in terms of both user preferences and the icons' perceived utility in supporting SA. Although participants perceived the current MilSTD 2525B representations as easiest for assisting them in monitoring friendly and enemy forces, the objective SAGAT measure showed that SA performance was highest using the proportional icon modality. Results are discussed in the context of designing unit representations to effectively support SA.

Strater, L. O., & Bolstad, C. A. (2009). Chapter 7. Simulation-Based Situation Awareness Training. In D.A. Vincenzi, J.A. Wise, M. Mouloua, & P.A. Hancock (Eds.), Human Factors in Simulation and Training. Boca Raton, Florida: CRC Press, Taylor & Francis Group.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section
Simulations in SA Research, Measurement, and Training
Simulations in SA Research
Simulations in SA Measurement
Simulations in SA Training
Structured SA-Oriented Training Development Process
Step 1: Identify Domain-Specific SA Requirements
Step 2: Identify and Develop SA Measures
Step 3: Identify SA Deficits within the Domain
Step 4: Develop Training Program to Target Selected Skills
Step 5: Validate Training Programs
Step 6: Identify Training Modifications Needed

Summary abstract:
The term situation awareness (SA) has been around since World War II. Although originally associated with military pilots, over the last several years it has emerged as a field of research in its own right and is now being examined in other domains, such as army operations, air traffic control (ATC), nuclear power plant operation, and medical applications (Bolstad, Riley, Jones, and Endsley, 2002; Collier and Folleso, 1995; Endsley, 1995a; Gaba, Howard, and Small, 1995; Sollenberger and Stein, 1995; Wright, Taekman, and Endsley, 2004). At its core, SA involves being aware of what is happening around oneself to understand how information, events, and one's own actions will affect one's goals and objectives, both now and in the near future. In fact, SA is employed regularly in the complex and dynamic tasks typical of everyday life, such as driving a car, crossing the street, or juggling items on a busy schedule. It is especially critical in work domains where the information flow can be quite high and poor decisions may lead to serious consequences (e.g., piloting an airplane, functioning as a soldier, or treating critically ill or injured patients).
As much of the study of SA has focused on those fields of endeavor where the consequences of poor SA can be quite severe, simulations have proved to be a valuable resource for both basic and applied research in these fields. Through simulations, one can safely and objectively investigate SA in many complex and critical tasks. Although SA is of great interest as a basic research topic, its applicability to realistic, everyday, yet critical tasks means that it is also of significant relevance in more applied work. This application-inspired perspective has initiated a process that begins with basic research on the nature of SA within a given field of investigation. Thus, much of the basic research has been driven by a desire to improve SA, and subsequently, performance. The research can then be used for developing objective measures that can guide the design and development of equipment, information displays, or training programs aimed at improving SA.
Operationally valid simulations provide an excellent vehicle to support these research and design efforts, particularly for training programs aimed at enhancing SA. Accordingly, the aim in this chapter is to describe how simulations can be employed throughout the process life cycle of training, design, and evaluation. We first provide some background information on the SA construct and the use of simulations in SA research, measurement, and training. We then introduce our structured SA-oriented training development process, including a discussion on basic

research and development of measures. We illustrate the application of this process with details from one of our research projects aimed at developing simulation-based SA training for infantry platoon leaders.

Strickland, J. L., & Gillan, D. J. (2003). Static and Dynamic Representations of Motion in Weather Displays. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making

Summary abstract:
Visual displays of weather information may provide valuable information for military command and control. Critical features of weather concern the movement of the weather system (e.g., rate and direction of movement). As a consequence weather displays need to provide users with motion information. The present research compared two static representations of motion (lines with arrowheads and plain lines), as well as an animated display that showed motion of weather systems on maps. In Experiment 1, participants observed a weather display, then answered questions concerning the rate and direction of the motion, the storm intensity, etc. The accuracy and speed of their responses were recorded. Participants were faster and more accurate when they had observed the static arrow display than the static line display, and were as fast and accurate with the static arrow display as with the animated display. In Experiment 2, participants observed an animated display of the weather and chose whether the static arrow display or the static line display contained the same information. They selected the static arrow display on 67% of the trials. The data suggest that a static arrow display provides motion information better than a static line display and, in these conditions, at least, as well as a dynamic display. The findings indicate that weather information systems may not require resource-intensive dynamic displays.

Strickland, J. L., Gillan, D. J., & Chadwick, R. (2003). Static and Dynamic Representations of Motion. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society, Conference. Denver, CO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Can static cues provide information about motion? The present research compared three types of displays that showed the motion of a weather system - two static displays (lines only and lines ending in arrows) and an animated display. In Experiment 1, participants received trials in which all three displays were presented and they selected the static display that best provided the motion information in the animated display. Participants selected the static arrow display on 67% of the trials. In Experiment 2, participants received trials with one display at a time, in which they used the display to answer questions concerning the motion of the weather system. Performance with the arrow (response time and accuracy) was better than with the static line and was comparable to the animated display. These results show that static cues can be interpreted in terms of motion.

Suri, N., Carvalho, M., Lott, J., Tortonesi, M., Bradshaw, J., Arguedas, M., and Breedy M. (2007). Policy-Based Bandwidth Management for Tactical Networks with the Agile Computing Middleware. In In Proceedings of IEEE Military Communications Conference (MilCom 2006) CD-Rom. New York: IEEE.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Bandwidth allocation and enforcement in tactical networks is a challenging problem. The mobile ad-hoc wireless environment is bandwidth constrained and the bandwidth required by applications running at any given moment in time typically exceeds the bandwidth available. In addition, both network topology and availability of network

resources vary rapidly in the mobile ad-hoc scenario. Therefore, it is important to properly realize allocation of bandwidth to the competing applications, monitoring of both available and assigned network resources, and the enforcement of constraints on channel usage.
IHMC's agile computing middleware and KAoS policy and domain services components provide a resource management platform that enables dynamic control of application bandwidth utilization in a transparent manner.
The agile computing middleware performs bandwidth monitoring and enforcement. It builds on top of the Mockets library for the realization of traditional client/server application-level communications. The middleware also integrates with the FlexFeed component to provide applications with publish-subscribe communications semantics and to support service-specific instream data manipulation.
The KAoS policy and domain services handle policy specification and distribution. KAoS policies can be used to specify bandwidth limits based on hosts, port numbers, and/or data flows.

Suri, N., Rebeschini, M., Breedy, M., Carvalho, M., and Arguedas, M. (2007). Resource and Service Discovery in Wireless Ad-Hoc Networks with Agile Computing. In In Proceedings of IEEE Military Communications Conference (MilCom 2006) (CD-Rom. New York: IEEE.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Resource and service discovery in tactical networking environments is a challenging problem. The ad-hoc and peer-to-peer nature of the network invalidates many traditional approaches to resource and service discovery that rely on registries. The agile computing middleware supports opportunistic service and resource discovery and tasking in tactical environments. The group manager component of the middleware supports bandwidth-efficient discovery of neighboring nodes, their resources (including CPU, memory, storage, and connectivity), and their services. Nodes may join one or more groups that allow resources and services to be categorized into related sets. Applications using the group manager are notified about the appearance and disappearance of peers as well as changes in memberships of groups. The group manager is efficient in finding neighboring services and is designed to improve the probability of finding resource-rich nodes. Crosslayer integration between the group manager and the MANET layer reduces the network overhead and improves performance.

Suri, N. (2009). Agile Computing and Adaptive Systems. In Invited seminar at the University of Modena and Reggio Emilia, Modena, Italy. June 4, 2009.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
• Agile Computing
- Agile Computing Overview
- Mockets Communications Library
- Group Manager Discovery service
- FlexFeed Publish-Subscribe System
- AgServe Service-oriented Architecture
- DisService Information Dissemination System
• Process Integrated Mechanisms
• Federated Information Spaces
• Work in Progress / Future Ideas
- DAIMS – Disaster Area Information Management System
- Information Oriented Networking
- Network Science

Summary abstract:
Agile Computing Definition
• Both a Metaphor and an Approach to Distributed Information Systems
• Design Systems to be

- Opportunistic in discovering, manipulating, and exploiting computing and communication resources
- Quick in reacting to changes in the environment
- Able to take advantage of the “wiggle room” available in the system

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Suri, N., Benvegnù, E., Tortonesi, M., Stefanelli, C., Kovach, J., & Hanna, J. (2009). Communications Middleware for Tactical Environments: Observations, Experiences, and Lessons Learned. IEEE Communications Magazine, 47(10), 56-63.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Tactical networking environments present significant challenges that must be overcome in order to effectively support net-centric warfare. The wireless and ad hoc nature of these networks implies unreliable connectivity, limited bandwidth, and variable latency. Past and current research has focused on physical and data link layers, routing protocols, transport protocols, and cross-layer aspects. However, significant work is needed at the upper layers to better support application requirements. In our experience, achieving effective communications in tactical environments requires taking into account application requirements and communication patterns, designing a rich interface between the application and communication layers, and realizing a communications middleware specifically adapted to tactical networks. In this article, we report on our observations from several tactical networking experiments and demonstrations and the lessons learned from deployment of the Mockets middleware to support tactical communications. We hope these experiences are useful to others designing and implementing applications and systems for tactical environments.

Suri, N., Bradshaw, J., Burstein, M., Uszok, A., Benyo, B., Breedy, M., Carvalho, M., Diller, D., Groth, P., Jeffers, R., Johnson, M., Kulkarni, S., & Lott, J. (2003). Toward DAML-Based Policy Enforcement for Semantic Data Transformation and Filtering in Multi-Agent Systems. In In Proceedings of 2nd International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS 2003). Melbourne, Australia.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Software agents have been proposed as a solution to integrate existing heterogeneous and stovepiped information systems. These capabilities extend agent autonomy to encompass communication and information exchange. However, in sensitive or critical application areas such as the military or competitive business environments involving proprietary information this kind of transparent interoperability raises concerns about the nature of the information being exchanged.
This paper describes an approach to provide runtime policy-based control over information exchange. Two different control mechanisms are discussed: semantic (content-based) filtering of messages as well as in-stream transformation of messages. Both of these control mechanisms are driven by policies at run-time. These mechanisms allow a far more fine-grained control over dynamic and autonomous agent interactions. With such an approach, we hope to increase the confidence with which system designers will adopt agent-based approaches to building dynamic, heterogeneous systems.
A companion paper [1] provides more details about the underlying KAoS policy and domain services and the NOMADS mobile agent system as well as the DAML-based representation of policies. The Coalition Agents Experiment (CoAX) which provided the testbed for this work is described in [2].

Suri, N., Bradshaw, J. M., Burstein, M. H., Uszok, A., Benyo, B., Breedy, M. R., Carvalho, M., Diller, D., Groth, P. T., Jeffers, R., Johnson, M., Kulkarni, S., & Lott, J. (2003). DAML-Based Policy Enforcement for Semantic Data

Transformation and Filtering in Multi-Agent Systems. In In Proceedings of Autonomous Agents and Multi-Agent Systems Conference (AAMAS 2003). Melbourne, Australia. New York, NY: ACM Press, pp. 1132-1133. Also in Proceedings of Third International Central and Eastern European Conference on Multi-Agent Systems (CEEMAS 2003). Prague, Czech Republic.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings Policies, Policy-based Control, Information Release Policies,
Semantic Filtering, Data Transformation Policies, Coalition
Operations, CoAX, CoABS Grid, DAML, DAML-S, KAoS,
Nomads.

Summary abstract:
This paper describes an approach to runtime policy-based control over information exchange that allows a far more fine-grained control of these dynamically discovered agent interactions. The DARPA Agent Markup Language (DAML) is used to represent policies that may either filter messages based on their semantic content or transform the messages to make them suitable to be released. Policy definition, management, and enforcement are realized as part of the KAoS architecture. The solutions presented have been tested in the Coalition Agents Experiment (CoAX) - an experiment involving coalition military operations.

Suri, N., Bradshaw, J. M., Carvalho, M., Breedy, M., Cowin, t., Saavedra, R., & Kulkarni, S. (2003). Applying Agile Computing to Support Efficient and Policy-Controlled Sensor Information Feeds in the Army Future Combat Systems (FCS) Environment. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003 (pp. 191-196). College Park, MD: U.S. Army Research Laboratory.

Key Words:
Human Performance

Summary abstract:
Agile computing is an approach to opportunistically discover and exploit available computing and communication resources to improve peiformance, faulttolerance, efficiency, and survivability. This paper describes the FlexFeed architecture that realizes the notion of agile computing in the context of the Army Future Combat Systems. FlexFeed provides efficient sensor information feeds while at the same time enforcing required policy constraints. FlexFeed tries to minimize network bandwidth utilization, distribute processing load across multiple nodes, and satisfy requirements on utilization of power-constrained devices.

Suri, N., Carvalho, M., Ansaloni, D., Arguedas, M., Benincasa, G., Bevegnu, E., Bradshaw, J. M., Breedy, M., Choy, S., Kovach, J., Marconi, M., Quitadamo, R., Tokarcik, M. R., Tortonesi, M., & Winkler, R. (2009). Chapter 3. Agile Computing and Its Applications to Tactical Military Environments. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section I. Collecting, Processing and Distributing Battlefield Information: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:

Agile computing is an innovative metaphor for distributed computing systems, which prescribes a new approach to their design and implementation. This chapter describes the overall agile computing metaphor as well as one concrete realization through a middleware infrastructure.
Agile computing may be defined as the opportunistic discovery, manipulation, and exploitation of available computing and communication resources in order to improve capability, performance, efficiency, fault-tolerance, and survivability. The term agile is used to highlight the desire to both quickly react to changes in the environment as well as to take advantage of transient resources only available for short periods of time. Agile computing thrives in the presence of highly dynamic environments and resources, where nodes are constantly being added, removed, and moved, resulting in intermittent availability of resources and changes in network reachability, bandwidth, and latency.
From a high-level perspective, the goal of agile computing is to facilitate resource sharing among distributed computing systems. At this broad level of description, agile computing overlaps with several other areas of research including distributed processing, peer-to-peer resource sharing, grid computing, and cluster computing.

Suri, N., Marcon, M., Quitadamo, R., Rebeschini, M., Arguedas, M., Stabellini, S., Tortonesi, M., & Stefanelli, C. (2008). An Adaptive and Efficient Peer-to-Peer Service-Oriented Architecture for Manet Environments with Agile Computing. In In Proceedings of Second IEEE Workshop on Autonomic Computing and Network Management (ACNM'08) Brazil.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Agile Computing, Peer-to-Peer, Service, Discovery, Service Migration, Service-oriented; Architectures, JXTA.

Summary abstract:
Realizing adaptive and efficient peer-to-peer Service-oriented Architectures for MANET environments is a challenging problem. In particular, robust and efficient service discovery and service migration are critical in the constantly changing and bandwidth limited MANET environments. In these scenarios, service migration lays the foundation for self-adaptive architectures. This paper describes the agile computing approach to peer-to-peer service discovery and service migration and provides a performance evaluation of these functions in the context of the Agile Computing middleware. The experimental results presented in the paper show that applications built on top of the Agile Computing middleware are capable of opportunistically exploiting transient computing resources in the MANET environment.

Suri, N., Rebeschini, M., Arguedas, M., Carvalho, M., Stabellini, S., & Breedy, M. (2007). Towards an Agile Computing Approach to Dynamic and Adaptive Service-Oriented Architectures. In In Proceedings of First IEEE Workshop on Autonomic Communication and Network Management (ACNM'07). New York: IEEE.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Terms-Agile Computing, Service-oriented Architectures, Dynamic and Adaptive Middleware

Summary abstract:
Agile computing is an innovative metaphor for distributed computing systems and prescribes a new approach to their design and implementation. Agile computing may be defined as opportunistically discovering, manipulating, and exploiting available computing and communication resources in order to improve capability, performance, efficiency, faulttolerance, and survivability.
This paper describes the realization of the middleware and the AgServe library that supports dynamic and adaptive serviceoriented architectures. The middleware supports service definition, instantiation, invocation, relocation, and termination to be performed dynamically at runtime. A coordination mechanism continuously monitors service resource utilization, invocation patterns, and network and node resource availability to determine optimal locations for services to be instantiated and invoked. The continuously adaptive nature of agile computing makes it well suited to providing a foundation for autonomic computing.

Suri, N., Tortonesi, M., Arguedas, M., Breedy, M., Carvalho, M., & Winkler, R. (2006). Mockets: A Comprehensive Application-Level Communications Library. In In Proceedings of MILCOM 2005 Conference, Atlantic City, NJ.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Mockets is a comprehensive communications library designed to address challenges specific to mobile ad-hoc networks. Mockets have been implemented at the application-level to simplify deployment and portability. Both stream-oriented and message-oriented abstractions are supported, with the message-oriented service providing multiple classes of service (reliable, unreliable, sequenced, unsequenced), message tagging and replacement, and prioritization. Mockets also interfaces with a policy management infrastructure to support bandwidth limitation. Finally, mockets supports transparent migration of communication endpoints across hosts without the need to terminate and reestablish connections. Mockets provides similar semantics to TCP but performs better than TCP on adhoc networks.

Talcott, C., Bennett, K. B., Martinez, S., Stansifer, C., & Shattuck, L. (2001). An Empirical Evaluation of Interfaces for Army Tactical Operations. In In Proceedings of 45th Annual Meeting of the Human Factors and Ergonomics Society. Minneapolis, MN.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Timely and accurate decisions in the Army domain are directly linked to the commander's ability to assess the battlefield. We reviewed both existing and proposed Army interfaces and applied a Cognitive Systems Engineering (CSE) approach to the development of an alternative interface: the RAPTOR interface (Representation Aiding Portrayal of Tactical Operations Resources). This interface and a version of the Army's recently-implemented digital interface (the Force XXI Battle Command Brigade and Below -- FBCB2) were evaluated using a simulated offensive scenario and domain experts from an active Army unit. The results indicate that the RAPTOR interface produced significantly better performance for quantitative, categorical and needs assessments. It is concluded that the RAPTOR interface summarizes critical information for Army units at all levels and makes this information easily accessible through effective graphical formats and interaction style.

Talcott, C. P., Bennett, K. B., Martinez, S. G., Shattuck, L. G., & Stansifer, C. (2008). Perception-Action Icons: An Interface Design Strategy for Intermediate Domains. Human Factors, 49(1), 120-135.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Objective: Aprototype interface was developed to support decision making during tactical operations; a laboratory experiment was conducted to evaluate the capability of this interface to support a critical activity (i.e., obtaining the status of friendly combat resources).
Background: Effective interface design strategies have been developed for domains that have primarily law-driven (e.g., process control) or intentdriven (e.g., information retrieval) constraints. However, design strategies for intermediate domains in which both types of constraints are equally critical, such as military command and control, have not been explored as extensively. The principles of direct perception, direct manipulation, and perception-action loops were used to develop a hybrid interface design strategy (“perception-action icons”) that was incorporated into the prototype interface.

Methods:Aqualitative tactical simulation and an alternative interface (an experimental version of an existing U.S. Army interface) were developed. Participants used both interfaces to provide estimates of friendly combat resources for three different categories of information at three different echelon levels.
Results: The results were unequivocal, indicating that the interface with perception-action icons produced significantly better performance.
Conclusion: The perception-action icon design strategy was very effective in this experimental context. The potential for this design strategy to be useful for other intermediate domains is explored.
Application: Actual or potential applications of this research include both specific interface design strategies for military command and control and general interface design principles for intermediate work domains.

Tate, A., Dalton, J., Bradshaw, J. M., & Uszok, A. (2005). Agent Systems for Coalition Search and Rescue Task Support. In In Proceedings of Third Workshop on Knowledge Systems for Coalition Operations (KSCO 2004). Pensacola, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The Coalition Search and Rescue Task Support project shows cooperative agents supporting a highly dynamic mission in which AI task planning, inter-agent collaboration, workflow enactment, policy-managed services, semantic web queries, semantic web services matchmaking and knowledge-based notifications are employed.

Tate, A., Dalton, J., Siebra, C. d., Aitken, S., Bradshaw, J. M., & Uszok, A. (2004). Intelligent Agents for Coalition Search and Rescue Task Support. In In Proceedings of Nineteenth National Conference on Artificial Intelligence (AAAI-2004). San Jose, CA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The Coalition Search and Rescue Task Support demonstration shows cooperative agents supporting a highly dynamic mission in which AI task planning, inter-agent collaboration, workflow enactment, policy-managed communications, semantic web queries, semantic web services matchmaking and knowledge-based notifications are employed.

Tate, A., Dalton, J., Uszok, A., & Bradshaw, J. (2004). Ai Planning for Grid/Web Services Composition, Policy Analysis and Workflow. In In Proceedings of DARPA DAML PI meeting. New York, NY.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
AIAI Summary Report
2003 Goal
– Link I-X coordination and task support with KAoS agent, domain and policy services
– Demonstrate in a Search & Rescue scenario in TTCP Binni C2 Domain
– To be shown as AAAI-2004 Intelligent Systems Demonstrator
http://www.aiai.ed.ac.uk/project/cosar-ts/demo/isd/
2004 Goal
– Create a web service composition tool based on AI planning technology that can account for execution policy issues, requirements and constraints
Release Plans
– Currently I-X version 3.3 and CoSAR demonstration are available via web for research use

– Open source I-X version 4.0 for research and US government use planned for September 2004. Tool based on this put on SemWebCentral soon after.
Plans to end of Project
– Do our best to package the results (effort mostly used to date)
– Do our best to continue to participate in SWSL and W3C SWS-IG

Thompson, L. F., & Gillan, D. J. (2010). Chapter 5. Social Factors in Human-Robot Interaction. In M. Barnes and F. Jentsch (Eds.), Human-Robot Interactions in Future Military Operations. London: Ashgate Publishing, Inc.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Much of this book centers on technical, usability issues pertaining to humans' interactions with robots. Although usability is a critical antecedent of technology acceptance, it is by no means the only determinant. Even an intuitive, easy-to-use robot will be disregarded if military personnel dislike it, distrust it, doubt it, or resent its ability to contribute effectively and efficiently to the mission at hand. Burke, Coovert, Murphy, Riley, and Rogers (2006) outlined four major HRI issues requiring attention from human factors professionals. Included on this list was the need to consider the factors driving acceptance of robots in work settings. The failure to accept a robotic assistant can result in situations where operators or soldiers sharing a field of operations with robots (1) do not place enough weight on the information or suggestions provided by the robot, (2) refuse to interact with the robot altogether, or (3) actively reject or react counter to the information from the robot (Madhavan, Wiegmann, & Lacson, 2006).
The purpose of this chapter is to discuss the social factors in HRI, especially as they affect the acceptance of robots and their integration into military teams. Implicit in the approach to this chapter is a broad use of the term "interface." Our use of "interface" covers any nexus of interaction between a human and robot, including both the means by which operators control and monitor the robot and, most importantly, the points of contacts between soldiers in the field and robots. Thus, the interface may involve social, as well as cognitive and perceptual interactions. With this in mind, we begin this chapter by considering the dynamics that may influence the acceptance of robots by individual and/or teams of soldiers. We then discuss a number of issues that emerge as robots are designed to interact with soldiers in social terms normally associated with human-to-human exchanges.

Tilak, R., Xholi, I., Schowalter, D., Ferris, T., Hameed, S., & Sarter, N. (2008). Crossmodal Links in Attention in the Driving Environment: The Roles of Cueing Modality, Signal Timing, and Workload. In In Proceedings of 52nd Annual Meeting of the Human Factors and Ergonomics Society. 22-26 September 2008. New York City, NY USA. New York City, NY USA: HFES.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Multimodal information presentation has been proposed as a means to support timesharing in complex data-rich environments. To ensure the effectiveness of this approach, it is necessary to consider performance effects of recently discovered crossmodal spatial and temporal links in attention, as well as their interaction with other performance-shaping factors. The main goals of this research were to confirm that performance effects of crossmodal links in spatial attention scale to complex environments and to examine how these effects vary as a function of cue modality, signal timing, and workload. In the present study, set in a driving simulation, spatially valid and invalid auditory and tactile cues preceded the presentation of visual targets at various stimulus-onset asynchronies and under different levels of workload induced by simulated wind gusts of varied intensity. The findings from this experiment confirm that visual target identification accuracies and response times are, overall, more accurate and faster when validlycued. Significant interactions were found between cue validity, stimulus onset asynchrony (SOA), and cue modality, such that valid tactile cueing is most beneficial at shorter (100 – 200 ms)

SOAs, while valid auditory cueing resulted in faster responses than invalid cueing at 500 ms SOAs, but slower responses at 1000 ms SOAs. Tactile error rates were significantly higher than auditory error rates at various interactions of modality and SOA. These findings were robust across all workload conditions. They highlight the need for context-sensitive information presentation and can inform the design of multimodal interfaces for a wide range of application domains.

Tinapple, D., & Woods, D. (2003). Message Overload from the Inbox to Intelligence Analysis: How Spam and Blogs Point to New Tools. In In Proceedings of 47th Annual Meeting of the Human Factors and Ergonomics Society Conference. Denver, CO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Patterns of responses to “message overload“ can be seen in the ways in which people adapt messaging systems and capabilities. Blogging is an effective and increasingly popular decentralized form of group communication that is proving useful in helping people find and share what is informative. We look to blogging for clues to new solutions to the problem of “data overload” in the world of email. These design solutions to email overload go beyond efforts to block spam, and are based on shifting the basic unit of organization toward communication relationships that allow patterns in communications to emerge.

Tittle, J. S., Roesler, A., & Woods, D. D. (2002). The Remote Perception Problem. In In Proceedings of 46th Annual Meeting of the Human Factors and Ergonomics Society. Baltimore, MD.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Previous research (e.g., Casper, 2002; Darken, Kempster, & Peterson, 2001) has shown that observers demonstrate poor spatial awareness based on video provided from remote environments. Such a result is understandable given that remote vision systems provide impoverished representations that leave out higher order cues essential to build coherent percepts and models of the world being explored. If tele-presence or remote vision is to be useful in the future, the raw video needs to somehow be augmented to recover what was lost by decoupling the human perceptual processor from the natural environment.

Tittle, J. S., Woods, D. D., Roesler, A., Howard, M., & Phillips, F. (2001). The Role of 2-D and 3-D Task Performance in the Design and Use of Visual Displays. In In Proceedings of 45th Annual Meeting of the Human Factors and Ergonomics Society. Minneapolis, MN.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Recent advances in computerized graphics capabilities have led to increased development and use of 3-D displays. In this paper we will discuss a survey of results from the visual perception literature that compares 3-D and 2-D task performance. The basic trend of this research suggests that designers of visual displays must recognize that the internal representations observers extract from 3-D displays will be distinctly different, and perhaps more qualitative, than the computer representations or models used to generate these displays. Finally, the surveyed literature indicates that crucial information in 3-D displays should not be encoded as differences in magnitudes of depth, orientation, or curvature. Instead designers should try to encode important task dimensions within more qualitative 3-D distinctions such as ordinal depth, deviations from co-planarity, and the presence of flat versus curved surfaces.

Toninelli, A., Bradshaw, J. M., Kagal, L., & Montanari, R. (2006). Rule-Based and Ontology-Based Policies: Toward a Hybrid Approach to Control Agents in Pervasive Environments. In In Proceedings of International Semantic Web Conference Policy Workshop (ISWC 05), Dublin, Ireland.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Policies are being increasingly used for controlling the behavior of complex multi-agent systems. The use of policies allows administrators to regulate agent behavior without changing source code or requiring the consent or cooperation of the agents being governed. However, policy-based control can sometimes encounter difficulties when applied to agents that act in pervasive environments characterized by frequent and unpredictable changes. In such cases, we cannot always specify policies a priori to handle any operative run time situation, but instead require continuous adjustments to allow agents to behave in a contextually appropriate manner. To address these issues, some policy approaches for governing agents in pervasive environments specify policies in a way that is both context-based and semantically-rich. Two approaches have been used in recent research: an ontology-based approach that relies heavily on the expressive features of Description Logic (DL) languages, and a rule-based approach that encodes policies as Logic Programming (LP) rules. The aim of this paper is to analyze the emerging directions for the specification of semantically-rich context-based policies, highlighting their advantages and drawbacks. Based on our analysis we describe a hybrid approach that exploits the expressive capabilities of both DL and LP approaches.

Tonti, G., Montanari, R., Bradshaw, J. M., Bunch, L., Jeffers, R., Suri, N., & Uszok, A. (2004). Automated Generation of Enforcement Mechanisms for Semantically-Rich Policies in Java-Based Multi-Agent Systems. In In Proceedings of First IEEE Symposium on Multi-Agent Security and Survivability (MAS&S 2004).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Policies are being increasingly used for controlling the behavior of complex systems (including agent systems). The use of policies allows administrators to specify agent permissions and obligations without changing source code or requiring the consent or cooperation of the entities being governed. Past approaches to policy representation have been restrictive in many ways. By way of contrast, semantically-rich policy representations can reduce human error, simplify policy analysis, reduce policy conflicts, and facilitate interoperability. However, semantically-rich policies increase the complexity of fielding policy-governed multi-agent systems. This paper discusses some technical challenges to automatically enforce semantically-rich security policies in Java-based multi-agent systems and presents an engineering approach for addressing some of these challenges. We have developed a first implementation that allows to enforce OWL policies represented using the KAoS policy framework into multi-agent systems built on top of the JDK1.4. The proposed solution allows to control the behavior of agents at a high level of abstraction and exploits the security mechanisms provided by the Java Authentication and Authorization Service (JAAS) to enforce OWL policies.

Tonti, G., Bradshaw, J. M., Jeffers, R., Montanari, R., Suri, N., & Uszok, A. (2004). Semantic Web Languages for Policy Representation and Reasoning: A Comparison of KAoS, Rei, and Ponder. In In Proceedings of International Semantic Web Conference (ISWC 03). Sanibel Island, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Policies are being increasingly used for automated system management and controlling the behavior of complex systems, allowing administrators to modify system behavior without changing source code or requiring the consent

or cooperation of the components being governed. Past approaches to policy representation have been restrictive in many ways. By way of contrast, semantically- rich policy representations can reduce human error, simplify policy analysis, reduce policy conflicts, and facilitate interoperability. In this paper, we compare three approaches to policy representation, reasoning, and enforcement. We highlight similarities and differences between Ponder, KAoS, and Rei, and sketch out some general criteria and properties for more adequate approaches to policy semantics in the future.

Trent, S. A., Patterson, E. S., & Woods, D. D. (2007). Challenges for Cognition in Intelligence Analysis. Journal of Cognitive Engineering and Decision Making, 7(1), 75-97.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Intelligence analysis is a high-stakes domain that poses challenges to effective individual and collaborative cognition. The design of support tools and analytical pedagogy could benefit from an understanding of how challenges that are reported in other decision-making literature generalize and are manifested in more naturalistic settings. The objective of this research was to elicit challenges for cognition in collaborative intelligence analysis. Two complementary research methods were used: unstructured interviews with 46 analysts and supervisors, and observations of eight teams of military intelligence analysts conducting a training scenario. Interviews with designers, educators, and practitioners in the intelligence community revealed trends in unsupported cognitive work and cultural challenges, whereas observations from a training exercise for army intelligence analysts instantiated other cognitive challenges of collaborative analysis. This study indicates that analytical style (part tradition and part due to individual reasoning tendencies) can result in premature narrowing, difficulty in reframing, and getting lost in the details. The study also illustrates the effects of friction within and across federated teams, how variable tempo can produce inexpert behavior, and considerations for the design of analytical support tools. This work suggests the value of complementary research methods in the study of other domains involving collaborative work. It is likely that these cognitive challenges affect other domains involving collaborative analysis. Finally, this study suggests that the effects of individual cognitive challenges are difficult to isolate in naturalistic settings and should most likely be considered collectively rather than independently.
Know the enemy and know yourself; in a hundred battles you will never be in peril. – Sun Tzu

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Trent, S. A., Smith, M. W., Zelik, D. J., Grossman, J. B., & Woods, D. D. (2009). Chapter 17. Reading Intent and Other Cognitive Challenges in Intelligence Analysis. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section III. Acting on Battlefield Information: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
Utilizing information for planning and decision making entails a process of analysis, which is subject to particular vulnerabilities given the demands confronting the analyst. In the context of military operations, intelligence analysis is a complex process involving many cognitive challenges. This project, through a series of studies, examined the cognitive challenges confronting intelligence analysts in their work.
Over the course of the project, three important themes have emerged:

First, capturing cognitive challenges of intelligence analysis requires methodological innovations. Requirements development methods which only look at normative "textbook" processes will fail to identify the challenges arising from complex situations, time pressures, resource limitations, and coping strategies. More naturalistic, ecologically valid methods are needed. However, the security constraints present in the intelligence domain require further innovations, such as more efficient utilization of limited access to the domain, and the use of non-classified analog scenarios. Multiple studies using complex but open source scenarios with professional analysts balanced these constraints in order to gain insight into cognitive challenges inherent in intelligence analysis.
Second, assessing analytic performance is best accomplished with a structured yet adaptive model of the process. What constitutes expert analytic performance varies depending on demands, resources, the nature of the problem, and the needs of the decision makers. No simple algorithmic approach can adequately reflect the necessary trade-offs expert analysts make. Therefore, we studied how professional analysts decide what is sufficiently rigorous in context, and developed a metric for assessing the rigor of analytic processes.
Third, reading the intent of others is both a core function of analysis, and a fundamental cognitive challenge in understanding complex social systems. Forecasting how a group will act in the future (including how the group might react to a Course Of Action) involves understanding the group's intentions. However, the research showed reading the intent of other groups accurately is complex and error prone.
The series of studies look at the challenges of intelligence analysis with respect to the following:
• The practice of analysis in real situations, with multiple teams, production demands, and environmental pressures (in other words, the Where, When, and with Whom of analysis)
• Reflections on the process of analysis, and interaction between analysis and supervisors/decision-makers (the How and for Whom)
• Analysis of other groups' structures and intentions (the What and Why)

Trent, S. A., Voshell, M., Grossman, J., Schoenwald, J., Patterson, E., Goldstein, S., Scherbarth, M., Tittle, J., & Dominguez, C. (2007). Federated Observational Research: A Unique Investigation Strategy for the Study of Distributed Cognition. In In Proceedings of K.Mosier & U. Fischer (eds.), Proceedings of the Eighth International Conference on Naturalistic Decision Making.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings ethnography, team cognition, observational research, intelligence analysis.

Summary abstract:
The study of team cognition in complex domains is typically hampered by two aspects – the concurrent, distributed nature of the cognitive work and the complexities of domain-specific tasks. Researchers unfamiliar with the work prior to observation may overlook critical vulnerabilities and interactions from simultaneous processes in multiple areas. In this study, an interdisciplinary observation team used unique variations on established ethnographic techniques. Rather than design a scaled world study, the research team first participated in a counter-insurgency intelligence training operation. This afforded a firsthand appreciation for critical tasks and operational language of the practitioners. The team then used a federated observation technique to simultaneously observe four independent squads of analysts conduct the same exercise. This paper outlines our methods and discusses some initial findings that suggest implications for support tool design, collaborative work and analytical pedagogy. It concludes with the benefits and limitations of our investigation strategy.

Troberg, E., & Gillan, D. J. (2007). Measuring Spatial Knowledge: Effects of the Relation between Acquisition and Testing. In In Proceedings of 51st Annual Meeting of the Human Factors and Ergonomics Society. Baltimore, MD.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Performance in human-robot interaction is related to the operator.s mental map of the space in which the robot travels. Accordingly, accurate assessment of mental maps will be important for the design of human-robot interfaces. The present research used a factorial design experiment to examine two methods for acquiring spatial

knowledge (reading a map vs. navigating in the space), three methods of testing spatial knowledge (drawing a map, navigating through the space, and estimating point-to-point distances. The results showed that performance in the navigation test was influenced by factors unrelated to the navigated distance, whereas map drawing especially was closely related to the actual distance. Map drawing resulted in a stronger relation between map distance and actual distance in the map training condition than in the navigation training condition. The results are interpreted in terms of transfer appropriate processing, and are applied to human-robot interface design.

Turner, G. A., Wang, G., & Winkler, R. (2003). An Agent-Based Shared Display Architecture. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures

Summary abstract:
Real-time information sharing is a critical factor in today's and tomorrow's battlefield and the Future Combat Systems. In this article, we propose a shared display architecture based on a software agent technique, which enables real-time sharing of large quantity GIS and tactical data among heterogeneous display devices in a network environment. We define the architecture by specifying the roles of the agent and the contributions it provides to the solution. We also offer an opinion comparing this agent-based approach with the traditional database mechanisms

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Tuzar, D., & Woods, D. D. (2006). Reorientation in Dynamic Situations. tuzar.1@osu.edu woods.2@osu.edu http://csel.eng.ohio-state.edu.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The activities of monitoring and controlling in event driven environments concerns in parallel tactical tasks as well as strategic tasks. Dynamic control environments often are mixed environments, real world and/or virtual worlds. Strategic and tactical operations are either perceived "through a window" showing a sector of a real world environment (real world), or virtually showing a virtual representation on a computer display (virtual world). Problem holders must focus their perceptual system, shift priorities, control tasks and sub tasks, and time share between tasks to succeed within such high density environments. Agents in artificial and high pace environments experience workload bottlenecks and data overload leading to critical situations or to failures of a complex system. This topic landscape explores the operators' difficulties in interacting with Human-Machine-Interfaces (HMI) for tactical tasks within event driven worlds, develops a conceptual space for reorientation, proposes a frame of reference for evaluating re-orienting costs, suggests design concepts, and relates findings to attention.

Uszok, A., & Bradshaw, J. M. (2008). Demonstrating Selected W3c Policy Languages Interest Group Use Cases Using the KAoS Policy Services Framework. In In Proceedings of 2008 IEEE Conference on Policy, Palisades, NY.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
KAoS, policy use cases, PLING, W3C

Summary abstract:
This demonstration will present policies and scenarios from selected W3C Policy Language Group use cases. The flexibility of the KAoS ontology-based policy services framework will be demonstrated by modeling the very diverse policies described in the use cases. The integration of the KAoS policy decision point (Guard) with the JBoss server will be shown. One of the use cases requires spatial reasoning for location-based policies.

Uszok, A., Bradshaw, J. M., Hayes, P., Jeffers, R., Johnson, M., Kulkarni, S., Breedy, M., Lott, J., & Bunch, L. (2004). DAML Reality Check: A Case Study of KAoS Domain and Policy Services. In In Proceedings of the International Semantic Web Conference (ISWC 03). Sanibel Island, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Description-logic-based knowledge representations and reasoning methods are being used increasingly as the basis for semantically-rich software services. Using such representations and reasoning methods in comprehensive applications is among one of the best ways to identify and understand gaps and limitations. KAoS domain and policy services, which rely extensively on a DAML-based ontology, are used as a case study to investigate an in-depth application of DAML. In this context, we explore the current limitations of DAML semantics. We also describe our observations about the place of ontology description at the heart of KAoS services, and outline requirements for effective interfaces for humans and for translation to and from efficient programming environments. Next, we present the problems implicated by development of ontology descriptions in a distributed dynamic environment. Finally, we assess the utility and maturity of available tools such as editors, programming libraries and inference engines. An application of KAoS to provide policies for DAML-S Web services concludes the paper.

Uszok, A., Bradshaw, J. M., Jeffers, R., Johnson, M., Tate, A., Dalton, J., & Aitken, S. (2004). Policy and Contract Management for Semantic Web Services. In In Proceedings of AAAI Spring Symposium. Stanford, CA., and Proceedings of IEEE Intelligent Systems, (July/August), pp. 26-35.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This paper summarizes our efforts to develop capabilities for policy and contract management for Semantic Web Services applications. KAoS services and tools allow for the specification, management, analyzes, disclosure and enforcement of policies represented in OWL. We discuss three current Semantic Web Services applications as examples of the kinds of roles that a policy management framework can play: as an authorization service in grid computing environments, as a distributed policy specification and enforcement capability for a semantic matchmaker, and as a verification tool for services composition and contract management.

Uszok, A., Bradshaw, J. M., Jeffers, R., Tate, A., & Dalton, J. (2005). Applying KAoS Services to Ensure Policy Compliance for Semantic Web Services Workflow Composition and Enactment. In In Proceedings of International Semantic Web Conference (ISWC 2004). Hiroshima, Japan.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In this paper we describe our experience in applying KAoS services to ensure policy compliance for Semantic Web Services workflow composition and enactment. We are developing these capabilities within the context of two applications: Coalition Search and Rescue (CoSAR-TS) and Semantic Firewall (SFW). We describe how this work has uncovered requirements for increasing the expressivity of policy beyond what can be done with description logic (e.g., role-value-maps), and how we are extending our representation and reasoning mechanisms in a carefully controlled manner to that end. Since KAoS employs OWL for policy representation, it fits naturally with the use of OWL-S workflow descriptions generated by the AIAI I-X planning system in the CoSARTS application. The advanced reasoning mechanisms of KAoS are based on the JTP inference engine and enable the analysis of classes and instances of processes from a policy perspective. As the result of analysis, KAoS concludes whether a particular workflow step is allowed by policy and whether the performance of this step would incur additional policy-

generated obligations. Issues in the representation of processes within OWL-S are described. Besides what is done during workflow composition, aspects of policy compliance can be checked at runtime when a workflow is enacted. We illustrate these capabilities through two application examples. Finally, we outline plans for future work.

Uszok, A., Bradshaw, J. M., Lott, J., Breedy, M., Bunch, L., Feltovich, P., Johnson, M., & Jung, H. (2008). New Developments in Ontology-Based Policy Management: Increasing the Practicality and Comprehensiveness of KAoS In In Proceedings of 2008 IEEE Conference on Policy, Palisades, NY.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
policy, ontology, OWL, KAoS, policy
management

Summary abstract:
The KAoS policy management framework pioneered the use of semantically-rich ontological representation and reasoning to specify, analyze, deconflict, and enforce policies [9, 10]. The framework has continued to evolve over the last five years, inspired by both technological advances and the practical needs of its varied applications. In this paper, we describe how these applications have motivated the partitioning of components into a well-defined three-layer policy management architecture that hides ontology complexity from the human user and from the policy-governed system. The power of semantic reasoning is embedded in the middle layer of the architecture where it can provide the most benefit. We also describe how the policy semantics of the core KAoS Policy Ontology has grown in its comprehensiveness. The flexible and mature architecture of KAoS enables straightforward integration with a variety of deployment platforms, ranging from highly distributed systems, such as the AFRL Information Management System, to human-robotic interaction, to dynamic management of quality-of-service and crossdomain information management of wireless networks in resource-constrained or security-sensitive environments.

Vanni, M., Voss, C. R., & Tate, C. (2004). Ground Truth, Reference Truth & “Omniscient Truth” -- Parallel Phrases in Parallel Texts for Mt Evaluation. In In Proceedings of Workshop on The Utility of Parallel and Comparable Corpora, Conference on Language Resources and Evaluation (LREC), Lisbon, Portugal. [Refereed].

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Recently introduced automated methods of evaluating machine translation (MT) systems require the construction of parallel corpora of source language (SL) texts with human reference translations in the target language (TL). We present a novel method of exploiting and augmenting these resources for task-based MT evaluation, assessing how accurately people can extract Who, When, and Where elements of information from TL output texts of different MT engines. This paper reports on the first phase of our research establishing a baseline MT evaluation process with (i) the construction and (ii) the annotation and inter-annotator rates of an annotated extraction corpus, and (iii) our results applying the corpus in the evaluation of three Arabic-to-English MT engines. In this corpus, the elements of interest are identified as parallel phrases across the parallel texts of the SL, the reference translations, and the MT engine outputs, where they are annotated and called, respectively the Ground Truth (GT), Reference Truth (RT), and Omniscient Truth (OT) items in the parallel texts. Our evaluation of three MT engines with the corpus yields precision and recall accuracy measures that, together with a loss measure, clearly rank the engines and, unlike other evaluation metrics, indicate diagnostically where output improvements will assist on extraction.

Veinott, B., Cox, D., & Mueller, S. (2009). Social Media Supporting Disaster Response: Evaluation of a Lightweight Collaborative Tool. In In Proceedings of Naturalistic Decision Making 9. London, UK.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Collaboration, Social Media, Design, Virtual Ethnography, Disaster Response

Summary abstract:
Motivation: Disaster response efforts rely heavily on ad hoc, cross organization teams with multiple stakeholders, who must collaboratively make sense of the situation, and are often working at a distance. These properties make it difficult to design collaborative tools in support of decision making in these environments.
Research Approach: In this paper we use virtual ethnographic techniques as a way to bridge the gap between important contextual and socio-technical conditions and early tool assessment. For an example case of some socio-technical issues, we discuss Twitter use during the San Diego, California wildfires in October 2007.
Findings: We found that Twitter supported some aspects of distributed collaboration well, but not others.
Originality: This research provided an early examination of the collaboration this form of connectivity supports which can be applied in several domains.

Veinott, E. S., Klein, G. A., & Wiggins, S. L. (2010). Evaluating the Effectiveness of the Premortem Technique on Plan Confidence.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Report

Summary abstract:
One problem affecting crisis management planning teams is overconfidence – an inflated belief that a plan will be successful. In this paper we compared the effect of several different methods for reducing individual team member confidence levels (Critique, Pros-Cons generation, Cons only generation, and a PreMortem) and compared each to a baseline control condition. One hundred and seventy-eight people participated in one of five conditions to evaluate an H1N1 plan in a university context. Participants provided several ratings of confidence in the plan's success over the course of the plan evaluation, generated reasons during their plan evaluation and provided subsequent confidence and understanding ratings. We compared several techniques commonly used (e.g., Critique, Devil's Advocate, Pro-Cons) and a newer technique, the PreMortem. The PreMortem technique (imagining that a plan has failed and then trying to explain why) reliably reduced confidence levels more than the other conditions, and may be useful in combating overconfidence in crisis management planning.

Voshell, M., & Oomes, A. H. J. (2006). Coordinating (Shared) Perspectives in Robot Assisted Search & Rescue. In In Proceedings of the 3rd International ISCRAM Conference (B. Van de Walle and M. Turoff, eds.), Newark, NJ.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Urban search and rescue, human-robot interaction, remote perception

Summary abstract:
From high fidelity field exercises to disaster response deployments, search and rescue robots are being readily integrated into rescue operations. Previous research has proposed that for such new technology to be successful in an operation the organization architecture needs to support the coordination of shared perspectives between the human team members and the robotic platforms. For this, the robot platforms need to be effective team players in the field of practice. Based on this conceptual model, this paper introduces a novel software interface utilizing virtual position and orientation indicators to alleviate perceptual ambiguities and navigation problems experienced by robot handlers and problem holders. By actively orchestrating and sharing these indicators between handler and operator displays, the interface caters to user expertise and to the natural competency of the human perceptual system. These probes provide a basic tool for aiding robot navigation and way-finding fundamental to effective team coordination and communication in urban search and rescue missions.

Voshell, M., Trent, S., Prue, B., & Fern, L. C. (2008). Cultivating Resilience in Urban Fire Fighting: Supporting Skill Acquisition through Scenario Design. In In Proceedings of 52nd Annual Meeting of the Human Factors and Ergonomics Society. 22-26 September 2008. New York City, NY USA. New York City, NY USA: HFES.

An Annotated Bibliography of Studies and Reports Produced by the Advanced Decision Architectures Consortium of the Collaborative Technology Alliance from 2001 to 2010

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Whether studying human cognition, designing new technologies, or exploring concepts such as safety and resilience, understanding decision making in natural settings is fundamental to Cognitive Systems Engineering (CSE). Across all of these, it is crucial for human factors engineers to be able to create realistic scenarios of interest that hit upon "cognitive pressure points" (Woods and Dekker, 2000) to elicit challenges and observe patterns in cognitive work. Although many converging methodologies have provided a rich ecological body of practice-based research and application, there is a shortage of research demonstrating the efficacy of scenario-based design in support of skill acquisition. Based on continuing research with a major metropolitan fire department, the current paper reports initial findings from ongoing work analysis. From a series of scenarios, patterns of coordination challenges are discussed with implications for future emergency response operations and training.

Voshell, M., Woods, D. D., & Phillips, F. (2005). Overcoming the Keyhole in Human-Robot Interaction: Simulation and Evaluation. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
When environment access is mediated through robotic sensors, field experience and naturalistic studies show robot handlers have difficulties comprehending remote environments - they experience what domain practitioners often call a 'soda straw'. This illustrates the keyhole effect in Human Robot Interaction, a CSE phenomena studied in the context of large virtual data space interfaces and the current research seeks to reduce this effect. A simulation for human-robot coordinated search and rescue was created based on WTC response experiences. Pilot studies showed traditional performance measures to be inadequate in analyzing control and exploration tasks therefore a novel analysis approach based on fractal path tortuosity was developed. New interface concepts for helping remote observers perceive environmental affordances were then tested using the simulation environment and evaluation measures. These studies look to concepts based on Gibsonian principles to reduce keyhole effects in control interfaces to enhance remote functional presence in Human-Robot Coordination.

Voshell, M. G., Woods, D. D., Prue, B., & Fern, L. C. (2007). Coordination Loops: A New Unit of Analysis for Distributed Work. In In Proceedings of K.Mosier & U. Fischer (eds.), Proceedings of the Eighth International Conference on Naturalistic Decision Making.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Joint Activity Theory, automated systems, teamwork, coordination loops.

Summary abstract:
Designing effective coordination into domains of distributed decision making and decentralized control is a daunting joint cognitive systems challenge. In order to support such coordination, it is necessary to look at modeling these systems from the perspective of coordination requirements. We propose "coordination loops" as a model that enables us to expand upon measures and constructs that allow specification requirements of distributed work to cultivate effective decision making across multiple domains.

Warwick, W. (2002). IICS IPT: The M&S of Decision Making. In In Proceedings of Integrated Infantry Combat System IPT. Quantico, VA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
•Goal: Improve realism in CGFs
–Generic prototype built around task-network modeling tools (Micro Saint, IMPRINT)
–Exploit a client-server architecture to "embed" behaviors in DIS or HLA-compliant CGF

Warwick, W. (2003). Developing Computational Models of Naturalistic Decision Making. In In Proceedings of Illinois Wesleyan University's Natural Sciences Colloquium.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Overview
•A rock and a hard place
•Theoretical background
•Our approach
–What it means to model a naturalistic decision computationally
–What it actually looks like in practice
–Reactions
•Reckless and inflammatory remarks

Warwick, W. (2003). Developing Computational Models of Naturalistic Decision Making. In In Proceedings of Behavior Representation in Modeling and Simulation Conference. Scottsdale, AZ.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
What Does It Mean To Develop a Computational Model of a Naturalistic Decision?
- Naturalistic theories of decision making discount rational choice models of decision making in favor of descriptive models
= Emphasis on experience, situation assessment and diagnosis rather than the deliberate analysis of alternatives
For the last three years we have been working toward a computational representation of Klein's model of the recognition-primed decision (RPD). After months of tweaking and refining in an attempt to capture theoretical nuances, we have finally begun a process of beta testing. So far, this has taken the form of a software release to a small, in-house team of modelers who are now applying our representation of the RPD to their own human performance models. Although our original development efforts revolved around working examples, we did not anticipate the variety of questions and insights that would arise with the fresh perspective of a new user (our in-house modelers were not part of the original development team). While some of these questions were the result of newly discovered bugs and usability issues, others pointed to fundamental assumptions we have made during the course of this work. We discuss these more fundamental issues. In particular, we describe how we are coming to terms with some of the limitations inherent in a computational representation of a naturalistic decision making process. We also discuss how we are beginning to appreciate the extent to which our approach to modeling decision making differs from those traditionally used in the development of Task-Network models. While we have occasionally indulged in a bit of sloganeering in past discussions of our work, we now believe we have identified some genuine methodological differences on which to recommend this "naturalistic" approach.

Warwick, W. (2003). Untangling Computational Intuitions About Naturalistic Decision Making In In Proceedings of Workshop on Cognitive Systems: Human cognitive models in system design. Hosted by Sandia National Laboratories and the University of New Mexico. Sante Fe, NM.

An Annotated Bibliography of Studies and Reports Produced by the Advanced Decision Architectures Consortium of the Collaborative Technology Alliance from 2001 to 2010

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Overview
The old tangle
Our approach
What it means to model a naturalistic decision computationally in general
What it actually looks like in practice
A new tangle

Warwick, W. (2004). Building a Cognitive Menu within a Cgf. In In Proceedings of 2004 Workshop on Cognitive systems: Human cognitive models in system design. Hosted by Sandia National Laboratories and the University of New Mexico. Sante Fe, NM.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
The Problem
•The behavioral realism of the synthetic entities that populate CGFs is lacking
–rigid, brittle and buggy
–impacts the use of M&S in both analysis and training
–divorced from theory
•No easy avenue for remediation
–no one wants you to mess with their V&V'd library and no one wants to start over
–lots of one-off efforts to "hook" individual behaviors

Warwick, W. (2009). Chapter 24. Understanding the Significance of Ada Research. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section IV. Communicating Information across the Team: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
Over the nine-year course' of the ADA, the Army has undertaken a variety oftechnological, organizational, and institutional changes. At the same time, the Army has been engaged in two long-term unconventional conflicts. The Army's transition to a digital battlefield conducted under the pressures of asymmetric warfare has led to significant transformations in tactics, equipment, a,nd leadership. This transition was characterized by accelerated technological transformations which increased the number of sensors on the battlefield, expanded use of unmanned and autonomous assets, and leveraged improvements in weapons lethality, responsiveness, and accuracy, while dramatically increasing distance between echelons. The cumulative effect of these conditions resulted in more decentralization of command with key decision-makingtasks pushed to lower and lower echelons. Combat in close quarters increased the speed of the "kill chain" and led to a commensurate shortening of the orient-observe-decide-act loop. The operational environment was further complicated by increased interdependence with other services, reliance on Multi-National Forces, and the demand to operate across different dimensions, including political, informational, economic, and social. At the tactical level of combat, daily operations decisively shifted from deliberate to more adaptive planning.

On the surface, ADA research could be viewed as a reaction to these new challenges; Indeed, much of the success of the ADA can be attributed to the commitment ADA researchers made to maintaining operational relevance. But the basic research ofthe ADA should not be viewed solely through the lens of today's circumstances. The science of the ADA is much more than a reaction to current technology trends and Army contingencies but, rather, rests in the development of a deeper understanding of the invariant challenges of warfare.

Warwick, W. (2009). Comparing the Comparisons. In Proceedings of the 18th Conference on Behavior Representation in Modeling and Simulation (BRIMS), Sundance, UT, 31 March - 2 April 2009.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Model comparison is becoming an increasingly common method in computational cognitive modeling. The methodology is seemingly straightforward: model comparisons invite the independent development of distinct computational approaches to simulate human performance on a well-defined task. Typically, the benchmarks of the comparison are goodness-of-fit measures to human data that are calculated for the various models. Although the quantitative measures might suggest that model comparisons produce “winners,” the real focus of model comparison is, or at least should be, on understanding in some detail how the different modeling “architectures” have been applied to the common task. And in this respect, the seemingly straightforward method of model comparison becomes more complicated.

Warwick, W., Allender, L., & Yen, J. (2009). Editors’ Introduction to the Special Issue on Developing and Understanding Computational Models of Macrocognition., Special Section of the Journal of Cognitive Engineering and Decision Making: Human Factors and Ergonomics Society (HFES).

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Newell and Simon (1976) once famously characterized computer science as an empirical inquiry—not merely an engineering discipline or a branch of applied mathematics but a science concerned with the discovery of the “essential nature” of symbol systems. Even more famously, they presented the physical symbol system and heuristic search hypotheses as candidate laws of the qualitative structure of intelligent systems. Their claims were not just about computers but about the nature of intelligence in general—namely, that the realization of a physical symbol system provides both necessary and sufficient conditions for intelligence and that the hallmark of such intelligence is the efficient search and testing of solutions within a problem space. It would be hard to overstate the impact of these hypotheses within the fields of artificial intelligence and cognitive science, as researchers since then have either elaborated these hypotheses or reacted to them.

Warwick, W., Archer, R., Hamilton, A., Matessa, M., Santamaria, A., Chong, R. S., Allender, L., & Kelley, T. (2008). Integrating Architectures: Dovetailing Task Network and Cognitive Models. In In Proceedings of Behavior Representation in Modeling and Simulation (BRIMS '08).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Task Network Modeling; Cognitive Modeling; C3TRACE; ACT-R

Summary abstract:

This paper describes our efforts to develop the Human Behavior Architecture (HBA), an integration of task network and cognitive modeling tools. We begin by describing the two component modeling tools we have integrated: C3TRACE, a task network modeling tool and the ACT-R cognitive architecture. Next, we describe the current state of the integration, highlighting practical aspects. We then turn to a discussion of conceptual issues that have surfaced as we put integration into practice. Finally, we discuss the benefit we see in this integration.

Warwick, W., & Archer, S. (2001). Incorporating Aspects of Human Decision Making in Task Network Simulation Tools. In In Proceedings of 2001 NATO RTA Conference on Future Modeling and Simulation Challenges. Breda, Breda, Netherlands, 12-14 November 2001, and published in RTO-MP-073.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In this paper we describe three ongoing projects intended to improve the representation of human decision-making in military simulations. Each project addresses a different aspect of decision making. The first project extends the functionality of the Improved Performance Research Integration Tool (IMPRINT) by allowing the user to create a detailed model of a goal-oriented human agent. A simulation running in IMPRINT predicts what the human is likely to do based on the currently relevant goals and the status of other parallel simulations. The focus of the second project is to predict the likelihood of a particular decision being made successfully given the quality of information available at the time the decision is made. The underlying idea is to use a task-network model to represent who knew what and when. In our third project, we are working to represent the human decision-making process in time-pressured, stressful situations. We have turned to Klein's theory of the Recognition-Primed Decision (RPD) as a model of what people actually do in such situations. RPD theory differs from traditional, analytical theories of decision making insofar as the emphasis lies on situation assessment rather than the comparison of options and thus poses a novel set of computational challenges.

Warwick, W., Brockett, C., McIlwaine, S., Hutton, R., & Hahn, B. (2002). Incorporating Models of Recognition-Primed Decision Making in Computer Generated Forces. In In Proceedings of Simulation Interoperability Workshop. Orlando, FL, SISO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Modeling and Simulation, Naturalistic Decision Making, Computer Generated Forces

Summary abstract:
In this paper we describe a six month effort undertaken by Micro Analysis and Design, Inc., and Klein Associates, Inc., to investigate a potential improvement to the representation of human decision making within computer generated forces (CGFs). Like other efforts, our work was motivated by the need to improve behavioral realism in CGFs and to bring theoretically grounded models of human performance to military simulations. Unlike other efforts, however, our approach to decision making was not rooted in the application of an integrative cognitive architecture. Instead we focused on individual "decision points" in the CGF and considered how we might supplant the routines at those points with "naturalistic" models of decision making intended to reflect what humans actually do in real situations.
Originally the main thrust of our effort was to investigate the extent to which we could implement a naturalistic representation within the OneSAF Test Bed environment. It soon became clear, however, that a significant additional effort was needed just to determine whether our approach was, in fact, leading to observable or interesting changes in entity performance. We briefly describe below the "decision points" we identified in the OneSAF Test Bed and how our naturalistic approach is realized within the OneSAF Test Bed environment. Next, we turn to a more extended discussion of the approach we took to determine whether our efforts were yielding interesting changes in decision making performance. In particular, we describe a pseudoSAF model we developed to help us isolate and understand individual behaviors in the OneSAF Test Bed. We then describe how our pseudoSAF lays the foundation for a more generic test architecture that will provide a controlled environment in which to compare new models of human performance against extant representations.

Warwick, W., & Fleetwood, M. (2006). A Bad Hempel Day: The Decoupling of Explanation and Prediction in Computational Cognitive Modeling. In In Proceedings of Fall 2006 Simulation Interoperability Workshop. Orlando, FL. SISO.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings Cognitive Modeling, Prediction, Explanation

Summary abstract:
The philosopher of science Gustav Hempel famously argued for the symmetry of prediction and explanation in scientific practice. Pointing to parallels in their logical structure, Hempel maintained that any adequate scientific explanation could engender a prediction, and vice versa. This symmetry is evident in the practice of computational cognitive modeling. Indeed, much of the motivation for computational cognitive modeling follows from the belief that process-level representations (i.e., the implementation of explanatory accounts of cognition) will lead to better predictions of cognitive performance and, conversely, that such predictions can be used to confirm or refute the accounts of cognition so-modeled. In this paper we present the results of a case study in which we undertook three very different modeling approaches to a well-known categorization task in experimental psychology. The approaches ran the gamut in terms of the commitments they made to the nature of the cognitive processes underlying the task. At the end of the day, however, each modeling approach yielded good and, moreover, essentially indistinguishable fits to the human performance data. So, what does it say about the relationship between prediction and explanation in cognitive modeling when three qualitatively different approaches yield quantitatively similar results? Several responses are possible. We canvass two such responses before discussing what we consider to be a more basic concern about computational approaches to cognitive modeling.

Warwick, W., & Hayes, P. (2003). Developing Computational Models of Naturalistic Decision Making: Methodologies and Perspectives. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making

Summary abstract:
In this paper we discuss several methodological issues that have emerged during our efforts to develop a computational model of a "naturalistic" decision making process. Our original goal was to improve the realism of computer generated forces by providing a framework to represent recognitional decisions. Along the way, we have come to appreciate the interplay between the decision maker's explicit knowledge (e.g., knowing which course of action is appropriate for a given set of cues) and implicit knowledge (e.g., knowing how much significance to attach to a particular cue in a given situation, how finely to resolve that cue, how much uncertainty to tolerate when assessing a situation, etc.). We have also come to recognize three things about modeling human decision making.: First, realistic human decision making cannot be represented solely in terms of expert knowledge and that we need to think as much about underlying process as we to overt procedure. Second, the representation of situated decision making behavior can benefit from the insights of both the cognitive modeling and artificial intelligence communities despite the fact that both traditions are often discounted by the Naturalistic Decision Making• community. Third, there are basic ontological and epistemological assumptions that underlie any representation of human behavior that are taken for granted all too often. Not surprisingly, the failure to account for these assumptions can lead to some deep confusions. We discuss each of these issues below in the context of our own work with an eye toward discovering a methodologically clear route to an improved understanding of human decision making, both conceptual and computational.

Warwick, W., & Hutchins, S. (2004). Initial Comparisons between a Naturalistic Model of Decision Making and Human Performance Data. In In Proceedings of 13th Conference on Behavior Representation in Modeling and

Simulation. Arlington, VA, SISO. pp. 73-78.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
In our past papers we have described the mechanics of a naturalistic model of decision making and we have outlined its performance in qualitative terms. In this paper we describe our initial attempts to compare the performance of our naturalistic model of decision making against human decision making performance. The human performance data were collected from an experiment independently conducted to determine how a graphical user interface might be best designed to support optimal decisions in a resource allocation task. Our goal was to model just one of the experimental conditions and see whether we could arrive at the same the allocation results using the highlevel representations supported by the naturalistic model. The initial comparisons have been promising, but they also raise interesting questions. We describe below both the experimental design and the naturalistic model that simulates that design. We then present the results of the quantitative comparison. Finally, we discuss some of the larger issues we see emerging from this comparison.

Warwick, W., & Hutton, R. J. B. (2007). Chapter 20. Computational and Theoretical Perspectives on Recognition Primed Decision Making. In R. Hoffman (Ed.), Naturalistic Decision Making (Vol. 6). Mahwah, NJ.: Lawrence Erlbaum Associates, Inc.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
A theme of chapters in this volume is the question of how experts cope with challenging, rare, or unusual problems, whether their expertise can transfer to novel situations, and how expertise can accommodate dynamic and uncertain situations. The goal is to understand how expertise is manifested when experts have to work "out of context." In this chapter, we take the theme at a 90-degree angle, as we try to understand expertise not just out of context, but out of body. Rather than discuss expertise stripped from familiar circumstances, we discuss expertise stripped from the expert. The discussion focuses on our attempts to develop a computational model of the recognition-primed decision (RPD) (Klein, 1993, 1998).
Our sense of disembodiment follows from the fact that we're trying to identify and computationally implement some of the invariant aspects of a Naturalistic Decision-Making (NDM) process. The ultimate goal of the computational work is not to develop a representation of this person making that decision, but rather, to develop a general architecture that can be applied to the representation of a variety of decision makers in a variety of real-world contexts. In turn, these representations should allow us to simulate decision making more realistically and in a manner with greater psychological plausibility than the probabilistic and rule-based representations in common use today in computational modeling.
From a theoretical perspective, one goal is to address the question of whether it is even possible to develop a computational model of an NDM process. Indeed, some might argue that naturalistic models of decision making are interesting precisely because their noncomputational nature seems to not fit with microscale representations (Klein, Ross, et al., 2003), and that it simply makes no sense to try to coerce macrocognitive phenomena into a computational framework. Second, if we assume it is possible to model such processes computationally, we must fix the level of abstraction at which we claim correspondence between the theoretical and computational model and we must clearly delineate the sense in which the resulting computational models are "naturalistic." As a third goal, we must establish a reciprocal relationship between the two models, not just one where the theoretical model informs the computational, but rather, where the computational model helps us explore aspects of the theoretical description that might remain underspecified.
In this chapter, we report on our progress toward these three goals. We begin with a brief overview of the theory and the computational model. Next, we turn to the question of how well the computational model represents the theory.

We describe several successive attempts we have made to model one of the several “by-products” of recognition posited by the RPD theory. Each iteration of this process has been instructive, in terms of both raising theoretical questions and identifying limitations in the computational representation. Finally, we describe the implications we see in this work for understanding the relation between the theory and computational model. This relationship has turned out to be more subtle than we expected, and it has caused us to rethink some of our most basic assumptions about the limitations of both the theory and the computational model.

Warwick, W., McIlwaine, S., Hutton, R., & McDermott, P. (2002). Developing Computational Models of Recognition-Primed Decision Making. In In Proceedings of 11th Conference on Computer Generated Forces and Behavior Representations. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings Decision Making, Recognition-Primed, Task-Network Modeling

Summary abstract:
In this paper we describe our ongoing work to develop a computational representation of Klein’s model of Recognition-Primed Decision making (RPD). The RPD model differs from traditional, analytical models of decision making insofar as RPD emphasizes situation assessment rather than the comparison of options. Like many efforts, our research is motivated by the need for improved realism in the behavior of Computer Generated Forces, and in particular, the need for better representations of human decision making. Unlike other efforts, however, our attempt to model RPD is not part of a more general model of cognition. We describe here the extent to which we have been able to model RPD apart from other aspects of cognition and we present the resulting RPD-specific architecture. We also point to the test bed environment we used for proof-of-concept and our current efforts to scale-up to a more complex decision making environment. Finally, we discuss our vision of a computational model of RPD as one tool in a suite of task networked based models of human decision making and the potential advantages that follow from this approach.

Warwick, W., & Santamaria, A. (2006). Giving up Vindication in Favor of Application: Developing Cognitively-Inspired Widgets for Human Performance Modeling Tools. In In Proceedings of 7th International Conference on Cognitive Modeling. Trieste, IT. Edizioni Goliardiche.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Computational models of cognition are most often developed to explore or vindicate particular theoretical views in psychology. The computer provides a ready environment in which to develop models and generate quantitative predictions about cognitive performance which, in turn, can be compared against actual human performance. Validating the model with a good fit vindicates the theoretical view the model implements. The resulting view of the cognitive modeling enterprise is decidedly hypothetico deductive. For all its familiar appeal, however, this is not the only reason to develop a cognitive model. In this paper, we describe our efforts to develop computational models of decision making that can be applied within existing human performance modeling tools. Although our efforts are inspired theoretically, the goal is not to vindicate this or that theoretical view of cognition but, rather, to engender sufficiently human-like behavior in a modeling environment where it is otherwise lacking. We begin by briefly describing the computational nuts and bolts we’ve developed for representing ‘naturalistic’ decisions in a task network modeling environment. We then point to results from several applications to demonstrate the flexibility of our approach and the extent to which it does really produce human-like behaviors, both quantitatively and qualitatively. We conclude by discussing the alternative, more instrumentalist view of the cognitive modeling enterprise that results when efforts are focused on the development of applications rather than architectures.

Warwick, W., & Santamaria, A. (2009). Chapter 15. A Computational Model of Naturalistic Decision Making and the Science of Simulation. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the

Warfighter: Foundations and Technology. Section III. Acting on Battlefield Information: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
With its roots in experimental psychology, computational cognitive modeling is most often seen as an exercise in theory testing. This view holds that theories of cognition are formalized as executable software programs; these programs are exercised as simulations of laboratory tasks to generate predictions that are then compared to actual human performance on those same tasks. Good fits validate good theories.
Although this view has received its share of scrutiny, most of the concern has focused on the finer points ofthe method (e.g., the quality of the data used for validation) while the most basic assumption of the entire enterprise-that theories of cognition can be expressed directly as computational models-remains unquestioned. Of course, some would argue that the relationship between cognitive theory and computer model is immediate. Indeed, Simon (1996) wrote, " ... if computers are organized somewhat in the image of man, then the computer becomes the obvious device for exploring the consequences of alternative organizational assumptions for human behavior ... " (pg. 21; emphasis added). Similarly, Newe" (1990) proposed that the layered abstractions of computing systems provide a useful approach for describing and understanding "knowledge systems." Even those who espouse a connectionist view of the human cognitive architecture (e.g., McClelland and Rumelhart, 1989) find comfort in computational models once the right functional units have been abstracted from the neurology. While cognitive modelers might debate the merits of symbolic versus distributed processing, they do not argue about the adequacy of productions systems or neural networks as computational models ofthose processes.
The concern here is that the seemingly direct relationships between the computational models and the cognitive theories they purport to represent are dependent on the theories themselves and not on any general understanding of the role of computer simulation in cognitive science. What happens when we consider a theory of cognition that doesn't happen to map easily or directly onto a computational architecture? What general guidance is there to decide what needs to be included in a cognitive model? Is there a theoretically neutral account of what constitutes a proper simulation? These are not idle concerns. In fact, nowhere are these concerns more present than when we look at the role of computer simulation in representing the macrocognitive theories of cognition (e.g., Cacciabue and Hollnagel, 1995). These theories are, in large part, predicated on a rejection ofthe view of cognition as information processing and they are typically couched in descriptive terms far above the level of detail where a "micro-level" process, neural or otherwise, might be implemented. Moreover, research in macrocognition is typically conducted "in the wild," beyond any laboratory control that might lend itselfto computational representation. Simulating and comparing performance on a problem solving task like the Towers of Hanoi is far easier than trying to capture the vagaries of expertise as it is applied in a dynamic and perhaps ill-structured real world domain.
In this chapter we report on our attempt to come to grips with these issues with the development of a computational model of the recognition- primed decision (RPD), a key function postulated by theories of macrocognition. We begin by describing the intended correspondence between the computational and theoretical model. We then briefly describe some tasks to which we've applied the model and the extent to which model predictions have fit human performance data. Though these applications provide a good degree of validation for the model, we conclude by discussing some of the broader implications we see in this kind of work for understanding cognitive modeling and simulation as a scientific endeavor.

Weil, S. A., Tinapple, D., & Woods, D. D. (2004). New Approaches to Overcoming E-Mail Overload. In In Proceedings of 48th Annual Meeting of the Human Factors and Ergonomics Society. New Orleans, LA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:

As e-mail has become the preferred medium for communication, the inbox and mail folders become one hub for organizing activities and schedule. The combination of a natural rise in message volume and the large amounts of unsolicited bulk messages (spam) have led some to suggest that the usefulness of e-mail is at an end; users feel overwhelmed by the sheer numbers of individual messages and the effort to manage the inbox. This paper frames the issue of e-mail/message overload as a specific example of data overload and uses previous results to suggest three design concepts – cognitive buoyancy, e-mail constellations, and the intelligent subject line – for use in e-mail.

Williges, R. C. (2005). An Invited Presentation Based on Project Activities Titled Interactive Applied Experimental Design and Analysis Tools for Engineering Psychology. In In Proceedings of Division 21 President's Invited Paper presented at the 2005 American Psychological Association Convention, Washington, D.C.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
1. Engineering Psychology Methods
– Research, Design, and Evaluation Methods
– Applied Experimental Design and Analysis
2. Example of an Online Tool
– Computer-Based Reference Material
– Interactive Reference Material Topics
3. Conclusions
– Characteristics of Effective Online Tools
– Online Toolkit Implication
4. Prototype Interactive Tool Demonstration

Williges, R. C., & Middlebrooks, S. (2007). Experimental Design Analysis of U.S. Army Command and Control Systems with the CADRE Tool. In In Proceedings of 25th Army Science Conference, Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Experimental Design; SAS;
Interval Estimation
Single-Sample t-Test
Between-Subjects t-Test
Within-Subjects t-Test
Chi-Square Goodness of Fit Test
Chi-Square Test of Independence (2x2 Contingency Table)
Chi-Square Test of Independence (RxC Contingency Table)
Chi-Square Test of Independence (Two Additive 2x2 Partitions)
McNemar Change Test
Cochran Q Test
Kolmogorov-Smirnov Tests
Kruskal-Wallis One-Way ANOVA
Wilcoxon Signed Ranks Test
Friedman Two-Way ANOVA
One-Factor, Between-Subjects ANOVA
Two-Factor, Between-Subjects ANOVA
Planned Comparisons
Unplanned Comparisons
Analysis of Interactions
One-Factor, Within-Subjects ANOVA
Two-Factor, Within-Subjects ANOVA
Geisser-Greenhouse and Huynh-Feldt Corrections

Testing Order Effects in Balanced Latin Squares
Within-Subjects and Between-Subjects
Design Comparison
Two-Way, Mixed-Factors ANOVA
Complete Hierarchical Between-Subjects Design
Partial Hierarchical Between-Subjects Design
Simple Blocking of 2k Within-Subjects Design
Complex Blocking of 2k Within-Subjects Design
One-Half Replicate of 24 Between-Subjects Design
Linear Correlation Coefficient
Alternative Linear Correlations
Simple Linear Regression
Analysis of Covariance (ANCOVA)
One-Way, Between-Subjects Design
Multiple Linear Regression
Best Regression Equation
Polynomial Regression
Orthogonal, Between-Subjects, Central-Composite Design
Blocked, Within-Subjects, Central-Composite Design

Summary abstract:
Previous work has involved experimental design interrogation of a series of computer models of human task and workload performance in military command and control (C2) systems. These models, called Computer modeling Of Human Operator System Tasks (CoHOST) (Middlebrooks et al., 1999), have shown a dramatic need for some tool to assist experimental designers in efforts to establish effective experiments. Specific needs include the collection of data in a manner that minimizes the amount of data required while maximizing the effectiveness and power of the data. A desktop tool called Computer-Aided Design Reference for Experiments (CADRE) was developed for this purpose. The CADRE tool includes over 850 pages of reference material covering 25 topics that are divided into five major sections including an introduction to experimental design, supplemental data collection design and analysis, basic analysis of variance (ANOVA) designs, advanced ANOVA designs, and empirical model building. In addition, the CADRE tool contains over 200 pages explaining 39 examples of statistical analyses covered in the reference material and is hyperlinked to Version 9.1.3 of the SAS statistical analysis package. The CADRE tool can be used for choosing experimental design procedures to interrogate and build empirical models in support of complex studies such as future C2 systems computer simulations.

Wojciechowski, J. Q., & Archer, S. G. (2002). Human Performance Modeling - Art or Science? In In Proceedings of Military, Government, and Aerospace Simulation (MGA 2002) Conference. Michael Chinni, (Ed.).

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Human Performance

Summary abstract:
Human performance modeling is being used in many different situations. It has been applied early in system acquisition in order to help influence the design so that the human functions more effectively as a system component. It has also been applied in operational testing, in order to provide guidance on how to best apply limited human-in-the-loop testing resources. These efforts have met with varying degrees of success, even when the same tool set is applied. Additionally, elaborate models and simulations have been built at great cost and effort, only to sit on the shelf because they did not effectively answer a relevant question. This has led to discussions about the level to which building a good human performance model or simulation is art versus science.
Admittedly, developing predictive human performance models is not an easy task. However, the human is one of the primary contributors to the variability in a system, and human performance modeling tools allow us to represent the human's role in the system early in the design phase so that we can develop systems that are more usable, maintainable, and supportable by their human components. Many believe that developing a model that effectively represents the human is an art -- that it takes years of practice and a fair amount of inherent talent to build good

human performance models. Others argue that it is an engineering exercise, and good science alone determines the predictiveness of the final result.
In this paper we explore those issues in order to better understand the key to creating good human performance models and modelers. We present several examples and point to elements of the models that determined their success. We conclude that good science is a necessary but not sufficient element of good human performance modeling.

Woods, D. (2005). Generic Support Requirements for Cognitive Work: Laws That Govern Cognitive Work in Action. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL. Also Invited talk. IBM Research Center.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Research in Cognitive Systems Engineering (CSE) has successfully identified basic requirements that must be met if new technology will be useful to practitioners in context. Synthesizing these basic requirements or support functions is part of a process of debate and consolidation of the foundations of the field after 25 years of productive activity (Klein, 1999; Endsley et al., 2003; Hollnagel and Woods, 2005). This work takes the “Laws that Govern Cognitive Work” which synthesize basic findings aand patterns (Woods, 2002; Hoffman and Woods, 2005) and provides the next step—a set of basic requirements or support functions for design. General requirements for effective support can be used to jump start individual development projects in any domain. Debating how to achieve these support functions helps translate the insights of cognitive work analyses into tangible new uses of technological possibilities.

Woods, D., & Christoffersen, K. (2001). Balancing Practice-Centered Research and Design. In M.D. McNeese and M.A. Vidulich (Eds.), Cognitive Systems Engineering in Military Aviation Domains, Pp. 121-136. Wright-Patterson AFB, OH: Human Systems Information Analysis Center (HSIAC).

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
Many are interested in R&D at the intersection of people, technology and work. Developers and technologists make claims about how a prospective new capability or new system development project will impact on performance in one or many settings. Sponsors are caught up in the sweeping dreams permitted by technology unfettered from harsh contexts of use, yet they fear software development projects that fail to provide useful tools or that create unanticipated negative effects. Practitioners and observers of practitioners at work note repeated forms of clumsiness in the technology deployed and unanticipated side effects of change. Researchers, blinded by the glare of disciplinary labels, drastically reduced situations to fit into a lab one variable at a time yet claim priority in the search for generic regularities. Human factors practitioners and usability engineers are called in too late to repair the connection between systems and use. Research results seem irrelevant to design. Design seems local and unique.

Woods, D., McNee, S., Davis, J. W., Morison, A., Maughan, P., & Christoffersen, K. (2005). Event Template Hierarchies as Means for Human-Automation Collaboration in Security Surveillance. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:

Advances in remote sensing systems provide human monitors access to more data. The current challenge is to help extract relevant patterns and direct the attention of human monitors and human problem holders to the changing security picture with respect to acute situations (a normal market scene turns into an ethnic confrontation) or longer term trends (seeing new patterns of 'typical' behavior to avoid false alarms). Security surveillance monitoring can be advanced through new event recognition capability of autonomous monitors and by effectively coupling these sensor/algorithm systems to human monitors and problem holders. To meet these challenges in security surveillance, we have developed an event-sensitivea rchitecturew here machine agents provide event-basedi nformationt o human monitors and problem holders and are re-directable given contextual information. The key innovation is a context-based hierarchical event template structure which can be used to integrate data over a distributed sensor system.a

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Woods, D. D., Patterson, E. S., & Roth, E. M. (2002). Can We Ever Escape from Data Overload? A Cognitive Systems Diagnosis. Cognition, Technology, and Work, 4(1): pp. 22-36.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Agent; Alarm; Context; Data overload; Information Visualisation; Workload

Summary abstract:
Data overload is a generic and tremendously difficult problem that has only grown with each new wave of technological capabilities. As a generic and persistent problem, three observations are in need of explanation: Why is data overload so difficult to address? Why has each wave of technology exacerbated, rather than resolved, data overload? How are people, as adaptive responsible agents in context, able to cope with the challenge of data overload? In this paper, first we examine three different characterisations that have been offered to capture the nature of the data overload problem and how they lead to different proposed solutions. As a result, we propose that (a) data overload is difficult because of the context sensitivity problem – meaning lies, not in data, but in relationships of data to interests and expectations and (b) new waves of technology exacerbate data overload when they ignore or try to finesse context sensitivity. The paper then summarises the mechanisms of human perception and cognition that enable people to focus on the relevant subset of the available data despite the fact that what is interesting depends on context. By focusing attention on the root issues that make data overload a difficult problem and on people's fundamental competence, we have identified a set of constraints that all potential solutions must meet. Notable among these constraints is the idea that organisation precedes selectivity. These constraints point toward regions of the solution space that have been little explored. In order to place data in context, designers need to display data in a conceptual space that depicts the relationships, events and contrasts that are informative in a field of practice.

Woods, D. D. (2002). Guts or No Guts (Grand Unified Theories): Does/Can/Should Cognitive Engineering Have G.U.T.S? In In Proceedings of 46th Annual Meeting of the Human Factors and Ergonomics Society. Baltimore, MD.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
What are the GUTs of Cognitive Systems Engineering (CSE)? G.U.T. is an abbreviation for Grand Unified Theory. As Cognitive Science matured, Allen Newell proposed a unifying model of cognition expressed as a software architecture SOAR. Similarly, John Anderson developed ACTR also claiming it represented a unified theory of cognition in the form of a computer simulation. Both of these cognitive architectures are computer programs that claim to simulate or be the basis for creating simulations of how people perform and learn cognitive tasks. Taking the development of Cognitive Science as a possible analogy for the potential development of Cognitive Systems

Engineering, this panel discussion provides a platform to stimulate a vigorous exchange of ideas about the foundation of and potential futures of CSE.

Woods, D. D., & Cook, R. I. (2002). Nine Steps to Move Forward from Error. Cognition, Technology, and Work, 4(2), 137-144.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Error; Failure in complex systems; Patient safety

Summary abstract:
Following celebrated failures stakeholders begin to ask questions about how to improve the systems and processes they operate, manage or depend on. In this process it is easy to become stuck on the label ‘human error’ as if it were an explanation for what happened and as if such a diagnosis specified steps to improve. To guide stakeholders when celebrated failure or other developments create windows of opportunity for change and investment, this paper draws on generalizations from the research base about how complex systems fail and about how people contribute to safety and risk to provide a set of Nine Steps forward for constructive responses. The Nine Steps forward are described and explained in the form of series of maxims and corollaries that summarize general patterns about error and expertise, complexity and learning.

Woods, D. D. (2002). Steering the Reverberations of Technology Change on Fields of Practice: Laws That Govern Cognitive Work. In In Proceedings of 24th Annual Meeting of the Cognitive Science Society. [Plenary Address]. Fairfax, VA.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Research on cognitive work in context has abstracted a set of common patterns about cognitive work and about the relationship of people and computers. I offer four families of Laws that Govern Cognitive Work plus Norbert’s Contrast as a synthesis of these findings to guide future development of human-computer cooperation. These Laws are one prong of a general strategy to avoid repeats of past "automation surprises".

Woods, D. D. (2003). Chapter 3. Discovering How Distributed Cognitive Systems Work. In E. Hollnagel (Ed.), Handbook of Cognitive Task Design (pp. 37-53). 10 Industrial Avenue, Mahwah, New Jersey 07430: Lawrence Erlbaum Associates, Inc.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
In cognitive work there is a mutual adaptation of agents' strategies, affordances of artefacts, and demands of the work setting. Regularities in cognitive work concern dynamic interactions across these sets of factors. Because cognitive work systems are not decomposable into independent basic elements, different empirical tactics are necessary, though core values of observation, discovery, and establishment of warrant remain fundamental guides.

Woods, D. D. (2003). Using Laws That Govern Cognitive Work to Design Human-Automation Systems. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures

Summary abstract:
Research on cognitive work in context has abstracted a set of common patterns about cognitive work and about the relationship of people and computers. I offer four families of Laws that Govern Cognitive Work plus Norbert's Contrast as a synthesis of these findings to guide future development of human-computer cooperation. These Laws are one prong of a general strategy to avoid repeats of past "automation surprises"

Woods, D. D. (2005). Generic Support Requirements for Cognitive Work: Laws That Govern Cognitive Work in Action. In In Proceedings of 49th Annual Meeting of the Human Factors and Ergonomics Society. Orlando, FL.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
Research in Cognitive Systems Engineering (CSE) has successfully identified basic requirements that must be met if new technology will be useful to practitioners in context. Synthesizing these basic requirements or support functions is part of a process of debate and consolidation of the foundations of the field after 25 years of productive activity (Klein, 1999; Endsley et al., 2003; Hollnagel and Woods, 2005). This work takes the "Laws that Govern Cognitive Work" which synthesize basic findings aand patterns (Woods, 2002; Hoffman and Woods, 2005) and provides the next step—a set of basic requirements or support functions for design. General requirements for effective support can be used to jump start individual development projects in any domain. Debating how to achieve these support functions helps translate the insights of cognitive work analyses into tangible new uses of technological possibilities.

Woods, D. D. (2005). Plenary Address: Supporting Cognitive Work: How to Achieve High Levels of Coordination and Resilience in Joint Cognitive Systems In In Proceedings of 7th International Conference on Naturalistic Decision Making. Amsterdam, The Netherlands. June 15-17, 2005.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
By studying joint cognitive systems in action, field oriented research has done more than identify basic patterns in the behavior--laws that govern cognitive work. A joint cognitive system perspective includes the artifacts and how they shape strategies and how they become tools through use. This means studying joint cognitive systems is an examination of co-adaptive cycles as people in different roles adapt to workaround complexities and exploit new capabilities. Thus, results from the field can be synthesized as a set of basic requirements that must be met if new technology will be useful to practitioners in context. Synthesizing these basic requirements or support functions is a critical part of a process of debate and consolidation of the foundations of the field after 25 years of productive activity.

Woods, D. D. (2006). Invited Plenary Address: The Law of Stretched Systems in Action: Exploiting Robots. In In Proceedings of Human-Robot Interaction Conference HRI'06, Salt Lake City, UT.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Human Factors, Design, Measurement, Reliability, Automation usage decisions, Trust, Agent

Summary abstract:
Robotic systems represent new capabilities that justifiably excite technologists and problem holders in many areas. But what affordances do the new capabilities represent and how will problem holders and practitioners exploit these capabilities as they struggle to meet performance demands and resource pressures? Discussions of the impact of new robotic technology typically mistake new capabilities for affordances in use. The dominant note is that robots as autonomous agents will revolutionize human activity. This is a fundamental oversimplification (see Feltovich et aI., 2001) as past research has shown that advances in autonomy (an intrinsic capability) have turned out to demand advances in support for coordinated activity (extrinsic affordances).
The Law of Stretched Systems captures the co-adaptive dynamic that human leaders under pressure for higher and more efficient levels of performance will exploit new capabilities to demand more complex forms of work (Woods and Dekker, 2000; Woods and Hollnagel, 2006). This law provides a guide to use past findings on the reverberations of technology change to project how effective leaders and operators will exploit the capabilities of future robotic systems. When one applies the Law of Stretched Systems to new robotic capabilities for demanding work settings, one begins to see new stories about how problem holders work with and through robotic systems to accomplish goals. These are not stories about machine autonomy and the substitution myth. Rather, the new capabilities trigger the exploration of new story lines about future operations that concern:
• how to coordinate activities over. wider ranges,
• how to expand our perception and action over larger spans through remote devices, and
• how to project our intent into distant situations to achieve our goals.
Research on these story lines provide new results on awareness of remote environments through robotic systems and brittleness/resilience in coordinating people and robots that define promising directions with high potential return for supporting work though robotic systems (Woods et aI., 2004). These results also help us identify new candidates for challenge cases in HRI and new classes of metrics (e.g., the fractal path scores developed by Phillips and Voshel).

Woods, D. D., Voshell, M., Roesler, A., Phillips, F., Feil, M. and Tittle, J. (2007). Podcast- the Law of Stretched Systems in Action: Exploiting Robots. In Podcast available at http://csel.eng.ohio-state.edu/podcasts/woods/.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
David Woods delivers the opening talk for the first annual Human-Robot Interaction Conference 2006. Robotic systems represent new capabilities that justifiably excite technologists and problem holders in many areas. But what affordances do the new capabilities represent and how will problem holders and practitioners exploit these capabilities as they struggle to meet performance demands and resource pressures?

Woods, D. D. (2009). Creating Foresight: Lessons for Enhancing Resilience from Columbia. In B. Starbuck and M. Farjoun (Eds.), Organization at the Limit: Nasa and the Columbia Disaster: Blackwell. (in press).

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book Chapter/Section

Summary abstract:
The past seems incredible, the future implausible.
To look forward and envision how organizations can achieve very high reliability and resilience, one first must look back with clarity unobscured by hindsight bias. The Columbia accident, as a highly visible event investigated in depth by a distinguished and independent panel, provides an opportunity to review generic patterns seen across multiple accidents and across studies in multiple fields of practice (Hollnagel, 1993). This chapter examines patterns present in the Columbia accident (STS-107) in order to consider how organizations in general can learn and change before dramatic failures occur.

Woods, D. D., & Hollnagel, E. (2006). Joint Cognitive Systems: Patterns in Cognitive Systems Engineering.: CRC Press, Taylor & Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487-2742.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Book

CHAPTER 1: CORE ACTIVITIES AND VALUES
Adaptability versus Limits
Complementarity
Core Values of CSE in Practice
On Systems in CSE
Patterns
Discovering Patterns in Joint Cognitive Systems at Work
A JCS at Work:

CHAPTER 2: JOINT COGNITIVE SYSTEMS ADAPT TO COPE WITH COMPLEXITY
Adaptation in Joint Cognitive Systems at Work

CHAPTER 3: BEING BUMPABLE (by R. I. Cook)
The Story: A Delay
The Intensive Care Unit: The Scene, the Cast, and Backdrop
Coping with Complexity: Parceling Out Beds by the Bedmeister
Artifacts as Tools: The Bed Book
Preparing for Demand > Supply Situations
Son of Coping: Building an ICU from Scratch
Piling Pelion on Ossa: Escalating Demands
Observations on the Incident

CHAPTER 4: DISCOVERY AS FUNCTIONAL SYNTHESIS
"Being Bumpable" as an Example of Studying a JCS at Work
Insight and Functional Synthesis

CHAPTER 5: SHAPING THE CONDITIONS OF OBSERVATION
Three Families of Methods
Converging Operations
The Psychologist's Fallacy

CHAPTER 6: FUNCTIONAL SYNTHESES, LAWS, AND DESIGN
Properties of Functional Syntheses
On Laws that Govern Joint Cognitive Systems at Work
Challenges to Inform Design
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CHAPTER 7: ARCHETYPICAL STORIES OF JOINT COGNITIVE SYSTEMS AT WORK
Demands and Adaptation
Affordances
Coordination
Resilience
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CHAPTER 8: ANOMALY RESPONSE

Control Centers in Action
Cascading Effects
Interventions
Revision
Fixation
Generating Hypotheses
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Control of Attention
Alarms and Directed Attention
Updating Common Ground When a Team Member Returns
Updating a Shared Frame of Reference
Patterns in Anomaly Response

CHAPTER 9: PATTERNS IN MULTI-THREADED WORK
Managing Multiple Threads in Time
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Escalation
Coupling
Premature Narrowing
Reframing
Dilemmas
Over-Simplifications

CHAPTER 10: AUTOMATION SURPRISES
The Substitution Myth
Surprises about Automation
Brittleness
Managing Workload inTime
Tailoring
Failure of Machine Explanation
Why is Technology So Often Clumsy?
Making Automation a Team Player
A Coordination Breakdown in Response to a Disrupting Event

CHAPTER 11: ON PEOPLE AND COMPUTERS IN JCSs AT WORK
Envisioning the Impact of New Technology
Responsibility in Joint Cognitive Sytems at Work
Problem-Holders
Goal Conflicts
Adapting to Double Binds
Literal-Minded Agents
Norbert's Contrast
Directions for Designing Joint Cognitive Systems that Include Robotic Platforms
Reverberations of New Robotic Technologies

CHAPTER 12: LAWS THAT GOVERN JCSs AT WORK
A Tactic to Reduce the Misengineering of Joint Cognitive Systems
Five Families of First Principles or Laws
Laws that Govern Joint Cognitive Systems at Work
Generic Requirements to Design Joint Cognitive Systems that Work
Design Responsibility
Patterns and Stories

Summary abstract:

The gadget-minded people often have the illusion that a highly automatized world will make smaller claims on human ingenuity than does the present one ... This is palpably false.
Norbert Wiener, 1964, p. 63

For almost 25 years, Cognitive Systems Engineering (CSE) has searched out and listened to stories of claims on human ingenuity as fields of practice have changed and adapted to new pressures, new devices, and new opportunities. In these stories, change challenged how activities are coordinated, how systems are resilient at boundaries, and how artifacts provide affordances.
This meant we could complement the previous book on joint cognitive systems, which focused on the foundational concepts, with a book that used stories of cycles of complexity and coping to show the main values, concepts and approaches of CSE in action. This book provides a way to look at our collective progress. The general storylines make up a base of [mdings and patterns that can be used to launch new studies of work, to project the effects of new rounds of change, to search out promising directions for innovating support. Ironically, thinking about representing a research base as a set of abstract narratives is in itself an exploration of how to support and enhance sharing technical, scientific and design information.
The stories told here are about more than the sharp end of practice. In parallel, each story tells another tale-revealing gaps and deficiencies in stories we tell ourselves about our relationship with technology, about how we accomplish our goals, and how our systems are vulnerable to breakdown. Acting in roles as researchers or designers or managers does not grant us any immunity from the processes and difficulties of coping with complexities.
One theme running through this volume is-swprise-that action is oriented to the future, anticipating or being prepared for what comes next. This book is intended to provide a start on a pattern base to help us be prepared to be surprised:
• As we observe joint systems at work in cycles of change and adaptation to come,
• As we envision with others how joint systems will work given new pressures and opportunities, and
• As we reflect on and revise our beliefs about work as one of the set of stakeholders whose beliefs support or hobble joint systems as they work.

Woods, D. D., & Sarter, N. B. (2010). Capturing the Dynamics of Attention Control from Individual to Distributed Systems: The Shape of Models to Come Theoretical Issues in Ergonomics Science (Special Issue on Situation Awareness). 11(1-2), 7-28.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
control of attention; situation awareness; layered sensing systems; neurobiology of attention

Summary abstract:
New technology presents opportunities for enhancing the performance of human systems that are tasked to meet multiple, often competing demands. Yet, mistakes in designing and deploying these technologies can create complexities that make human systems more brittle. To many stakeholders, the answer to this challenge is increase situation awareness. But what these advocates refer to when they talk about enhancing situation awareness varies tremendously. Over 15 years ago, the authors commented on how the label was ill defined. Today, the label is more popular than ever but the range of situations and the kinds of awareness are now so diverse that the label is better referred to as multiply defined. This paper returns to basic concepts and findings about human perception and the control of attention and the critical role that these processes play in individual as well as joint and distributed activity – how people know where to focus next in changing situations. This paper also briefly reviews recent studies on the neurobiology of the control of attention that help explain how people find what is relevant despite the fact that this is highly context sensitive. Together, the findings from this research can be synthesised into new models that capture how human systems can fluently and dynamically shift focus as context, goals and situations change. These models are needed to be able to understand, predict and support the processes involved in assessing situations and achieving situation awareness. They can be scaled up to address environments where technology is used to extend human perception into distant scenes and where technology connects multiple interdependent agents (both human groups and machine agents) over new temporal and spatial scales.

Woods, D. D., Tittle, J., Feil, M., & Roesler, A. (2003). Supporting Human and Robot Coordination. In In Proceedings of Collaborative Technology Alliances Conference 2003. Science and Technology Innovations for the Objective Force. April 29 - May 1, 2003. University of Maryland University College, Adelphi, Maryland: U.S. Army Research Laboratory.

Key Words:
CTA, Collaborative Technology Alliance, Advanced Decision Architectures; decision making

Summary abstract:
Developers of autonomous capabilities underestimate the need for coordination when their automata are deployed into complex operational settings. Automata are brittle as literal minded agents and there is a basic asymmetry in coordinative competencies between people and automata. The new capabilities of robotic platforms raise new questions about how to support coordination. This paper presents a series of new questions for innovation in humanrobot coordination. These include supporting people in their roles as problem holder and as robotic handler, overcoming ambiguities in remote perception, avoiding coordination surprises by better tools to see into future robotic activities and contingencies, and responsibility in human-robot teams.

Woods, D. D., Tittle, J., Feil, M., & Roesler, A. (2004). Envisioning Human-Robot Coordination for Future Operations. IEEE SMC Part C, 34(2), 210-218.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article
Affordances, design methods, human-automation interaction, human–robot-interaction, presence, remote perception.

Summary abstract:
Developers of autonomous capabilities underestimate the need for coordination with human team members when their automata are deployed into complex operational settings. Automata are brittle as literal minded agents and there is a basic asymmetry in coordinative competencies between people and automata. The new capabilities of robotic systems raise new questions about how to support coordination. This paper presents a series of issues that demand innovation to achieve human–robot coordination (HRC). These include supporting people in their roles as problem holder and as robotic handler, overcoming ambiguities in remote perception, avoiding coordination surprises by better tools to see into future robotic activities and contingencies, and responsibility in human–robot teams.

Yang, G.-H., Jones, L. A., & Kwon, D.-S. (2008). Use of Simulated Thermal Cues for Material Discrimination and Identification with a Multi-Fingered Display. Presence, 17(I), 29-42.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
Thermal cues provide information about the thermal properties of an object held in the hand. These cues can be simulated in a thermal display and used to assist in identifying the object. Two experiments were conducted using a thermal display that simulated the cues associated with contact with different materials. The thermal contact model was based on a semi-infinite body model that included thermal contact resistance and blood perfusion. Its performance was evaluated in two experiments, the first of which involved discriminating between simulated

materials, and in the second, subjects were required to identify simulated materials based on the thermal cues presented to one, three, or five fingers. The results from the first experiment indicated that when the temperature profile associated with contact with a real material is presented to the finger, subjects can use this cue to discriminate between simulated materials. Their performance on this task is comparable to that achieved with real materials with similar thermal properties. In the second experiment, the accuracy with which subjects identified a simulated material based on thermal cues improved as the number of fingers stimulated increased, suggesting that spatial summation of cold occurs when the area stimulated is noncontiguous. However, most of the improvement in identifying materials occurred when the display presented thermal cues to three as compared to one finger, with little further enhancement in performance when five fingers were stimulated. These results indicate that thermal displays can be used effectively to present information about the material composition of objects in virtual environments.

Yang, G.-H., Kwon, D.-S., & Jones, L. A. (2009). Spatial Acuity and Summation on the Hand: The Role of Thermal Cues in Material Discrimination. Attention, Perception & Psychophysics. The Psychonomic Society, Inc., 71(1), 156-163.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:
The spatial characteristics of thermal perception were studied in two experiments that examined how thermal stimuli are processed within the hands. A thermal display that simulates cues associated with making contact with different materials was used in these studies. In the first experiment, participants indicated which of two simulated materials that were presented to the index fingertip was cooler. The results indicated that participants were unable to resolve the two areas of thermal stimulation. In the second experiment, the effects of concurrent thermal stimulation on the ability to discriminate between simulated materials were evaluated. Thermal cues were presented to the middle fingers of both hands and to two adjacent fingers on one hand. Thermal spatial summation was evident across the fingers, which enhanced the ability to discriminate between materials when the cooler stimulus was presented to three fingers. When the same stimulus was presented to the two hands, the stimulation of adjacent fingers altered the perceived thermal response.

Yen, J., Strater, L., McNeese, M., Fan, X., Cuevas, H. M., Oh, S., Kim, A., Minotra, D., & Hanratty, T. (2009). Chapter 12. Cognitively-Inspired Agents as Teammates and Decision Aids. In P. McDermott and L. Allender (Eds.), Advanced Decision Architectures for the Warfighter: Foundations and Technology. Section II. Presenting Battlefield Information to Warfighters: 48hrBooks by Alion Science & Technology Corporation under contract to the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005, Human Research and Engineering Directorate. Proceedings from the Advanced Decision Architectures (ADA) group of the Collaborative Technology Aliance (CTA) Final Research Management Board Meeting and Workship titled: Supporting the Soldier Decision Maker. July 22-23, 2009. 1100 New Jersey Avenue SE, Suite 200, Washington, D.C. 20003. http://bldr-webtest.alionscience.com/AdaCta/Agenda.aspx.

Key Words:
Collaborative Technology Alliance, CTA, Advanced Decision Architectures, ADA

Summary abstract:
The advancement in sensor, communication, and information technologies have resulted in information-dense environments in which current and future warfighters must operate. In the face of dynamic, constantly changing events and conflicting reports, this vast amount of information makes it difficult for warfighters to develop and maintain a clear picture of the operational situation. This difficulty is further compounded by the challenges of asymmetric warfare where complex decisions that consider multi-dimensional factors (e.g., human, social, and cultural factors) are required not only for strategic planning, but also at the operational and tactical level, across all echelons.

To address these challenges, this research, supported by the Advanced Decision Architectures Collaborative Technology Alliance of the U.S. Army Research Lab, aims to achieve two complimentary research goals. Our first research objective is to develop a cognitively-inspired decision agent architecture that supports the delivery of relevant information to decision-makers in a timely fashion. These software agents act as both teammates and decision aids, enhance the human's capability in reasoning across multiple decision spaces, and enable dynamic team collaboration among decision makers. With its cognitive foundations, functions and components in such an architecture can be better related to the processes of human cognition. Such a relationship between computational decision aids and human decision process can contribute to the co-refinement of both the computational decision architecture and the human-agent team cognition theory.

Our second research objective is to study factors that affect humanagent interactions such that warfighters can better calibrate their automation usage and maintain global situation awareness (SA). Despite the best intentions of automation designers, the current state of technology does not produce perfect automation. On the battlefield, for example, automation, like humans, must function in the face of uncertainty and in sub-optimal environmental conditions. Warfighters, trained to operate in teams, understand that these complexities may affect the judgments of their human teammates, but sometimes fail to realize that agent teammates can be similarly affected. When warfighters fail to adequately understand the factors influencing the performance of their agent teammates, they may make poor automation usage decisions (AUDs) and may fail to appropriately trust their agent teammates. Previous research has shown that trust in team members, whether human or agent, is critical in mediating team operations, particularly with increasing levels of cognitive complexity.

The objective of our cognitively-inspired agent system (R-CAST) is to serve as decision aids and teammates of human decision makers. There are many normative, descriptive, and prescriptive decision theories that can be built within an agent system. We chose to adopt Klein's RPD model (Klein, 1997) in R-CAST for several reasons. First, the RPD model is a holistic model of human decision making processes, including activities such as seeking relevant missing information, and monitoring expected outcomes of decisions to detect anomaly. Second, operators can more easily understand a decision aid based on a naturalistic decision process (e.g., macro-cognitive process described in RPD) due to his/her familiarity and experience with the process. This encourages active human-agent collaboration along the decision process. Such a decision aid would be intelligent not only in the evaluation and choice of options, but also in social interactions with human decision makers.

With a computational RPD model as the macro-cognitive process, the R-CAST system has been used in a series of experimental studies toward a better understanding of human-agent collaboration in time stressed decision making situations. The first experiment was conducted to help us to understand whether future warfighters can benefit from R-CAST in handling complex multi-dimensional decision tasks. Being a teammate of a human decision maker, the R-CAST system ought to be trustable and understandable. The second and third experiments examined the issue of human-agent trust and raised the interesting question of how to facilitate a suitable level of trust between warfighters and decision aids to Improve the overall performance of the human-agent team. The fourth experiment was conducted to evaluate the impact of providing a mental map visualization ofthe agent's decision space to promote automation transparency on effective human automation-usage decisions.

The rest of the chapter is organized as follows. In section 2, we describe related research regarding human-agent team cognition and its relationship to human trust in agents. In section 3, we describe the RCAST agent architecture, which is empowered by a computational RPD model. In section 4 we give an overview of a synthetic task designed for studying multi-dimensional decision making. In section 5, we summarize a series of human-in-the-Ioop experiments where the R-CAST agents served as teammates and decision aids, investigating the issue of multicontext decision making, human-agent trust, and mental map visualization. Finally, we discuss the impacts of our work and point to some directions for future studies.

Zachary, W., Neville, K., Fowlkes, J., & Hoffman, R. R. (2007). Human Total Cost of Ownership: The Penny Foolish Principle at Work. IEEE Intelligent Systems, pp. 22-26.

Key Words:
ADA CTA
Advanced Decision Architectures
Collaborative Technology Alliance
Journal Article

Summary abstract:

This essay taps a recurring topic in this department: procurement. Human-centered computing is about creating technologies that are intelligent in the usual sense of intelligent systems. But we also mean intelligent in the sense that they are

• usable versus user-hostile;
• useful because they're designed on the basis of results from cognitive task analysis, so that they actually help people do things that need to be done; and
• understandable, in that the human can learn what the machine is doing and why.

Unfortunately, the procurement processes we see often don't achieve these ends. New tools called decision aids or performance aids trigger a need for kluges—that is, they're rarely usable. Machines wind up collecting dust—they're not useful. Menus cause user rage—they're not understandable. All too often we see instances of this Penny Foolish Principle of complex cognitive systems:
A focus on short-term cost considerations, as a main driving force in procuring new information technology, always comes with a hefty price down the road, a price that always weighs most heavily on users' shoulders.
Countless program managers, system designers, computer scientists, human-factors engineers, and cognitive systems engineers have participated in projects culminating in technologies that were highly constrained by shortterm cost factors. In many instances, such short-term considerations came back as hauntings.

Zelik, D., Patterson, E. S., & Woods, D. D. (2007). Understanding Rigor in Information Analysis: The Role of Rigor in Professional Intelligence Analysis. In In Proceedings of the Eighth International NDM Conference, (Eds. K. Mosier & U. Fischer). Pacific Grove, CA, June 2007.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings
Rigor, analytical rigor, information analysis, intelligence analysis

Summary abstract:
Across information analysis domains, it is often difficult to recognize when analysis is inadequate for a given context. A better understanding of rigor is an analytic broadening check to be leveraged against this uncertainty. The purpose of this research is to refine the understanding of rigor, exploring the concept within the domain of intelligence analysis. Nine professional intelligence analysts participated in a study of how analytic rigor is judged. The results suggest a revised definition of rigor, reframing it as an emergent multi-attribute measure of sufficiency rather than as a measure of process deviation. Based on this insight, a metric for assessing rigor was developed, identifying eight attributes of rigorous analysis. Finally, an alternative model of briefing interactions is proposed that integrates this framing of rigor into an applied context. This research, although specific in focus to intelligence analysis, shows the potential to generalize across forms of information analysis.

Zelik, D. J., Patterson, E. S., & Woods, D. D. (2007). Judging Sufficiency: How Professional Intelligence Analysts Assess Analytical Rigor. In In Proceedings of 51st Annual Meeting of the Human Factors and Ergonomics Society. Baltimore, MD.

Key Words:
ADA CTA; Advanced Decision Architectures; Collaborative Technology Alliance; Conference Proceedings

Summary abstract:
This study examines how professional intelligence analysts judge the rigor behind an analysis. The study investigates the challenges that inhibit the understanding of rigor in intelligence analysis and explores cues used by analysts to identify analytic rigor—or lack of rigor. Nine professional intelligence analysts participated in a modified elicitation by critiquing method study, embedded in a scenario walkthrough. Findings from the study indicate that, while professional intelligence analysts can make perceptive assessments about the quality of an analysis process based on product quality, these perceptions are apt to change with insight into the analytic process.

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4. Distribution.

This report shall be distributed to the following reciepients:

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